Exhibit X

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SPIN MASTER LTD.,
Petitioner

v.

SPHERO, INC.,
Patent Owner.

Case No. IPR2017-01272
U.S. Patent No. 9,211,920 B1

DECLARATION OF DR. JASON JANÉT

I, Jason Janét, hereby declare the following:

I. INTRODUCTION

1. I, Jason Janét, have been retained by counsel for Petitioner as a technical expert in the above-captioned case. Specifically, I have been asked to render certain opinions in regards to the IPR petition with respect to U.S. Patent No. 9,211,920 ("the '920 Patent"). I understand that the Challenged Claims are claims 1-3, 6-11, 13-18, and 21. My opinions are limited to those Challenged Claims.

2. In reaching my opinions in this matter, I have relied on the following materials:

- U.S. Patent No. 9,211,920 to Bernstein, et al. (Exhibit 1001);
- U.S. Patent No. 8,269,447 to Smoot et al. (Exhibit 1009);
- U.S. Patent Application Publication No. 2012/0168240 to Wilson et al. (Exhibit 1010);
- U.S. Patent No. 6,584,376 to Van Kommer (Exhibit 1011);
- U.S. Patent No. 933,623 to Cecil (Exhibit 1014);
- U.S. Patent No. 1,263,262 to McFaul (Exhibit 1015);
- U.S. Patent No. 2,949,696 to Easterling (Exhibit 1016);
- U.S. Patent No. 4,541,814 to Martin (Exhibit 1017);
- Masato Ishikawa, Ryohei Kitayoshi, and Toshiharu Sugie, Dynamic rolling locomotion by spherical mobile robots considering its generalized momentum, Proceedings of SICE Annual Conference 2010 2311 (2010) (Exhibit 1018);
- Aarne Halme, Torsten Schönberg and Yan Wang, Motion Control of a Spherical Mobile Robot, 4th International Workshop on Advanced Motion Control 259 (1996) (Exhibit 1019);
- U.S. Patent No. 4,601,675 to Robinson (Exhibit 1020);
- Daliang Liu, Hanxv Sun, Qingxuan Jia, and Liangqing Wang, Motion Control of a Spherical Mobile Robot by Feedback Linearization, Proceedings of the 7th World Congress on Intelligent Control and Automation 965 (2008) (Exhibit 1021);

- Hashem Ghariblu and Hadi Mohammadi, Structure and Dynamic Modeling of a Spherical Robot, 8th International Symposium on Mechatronics and its Applications (2012) (Exhibit 1022);
- Xialing Lv and Minglu Zhang, Robot Control Based on Voice Command, IEEE International Conference on Automation and Logistics 2490 (2008) (Exhibit 1023);
- Qiang Zhan, Yao Cai, and Caixia Yan, Design, Analysis and Experiments of an Omni-Directional Spherical Robot, IEEE International Conference on Robotics and Automation 4921 (2011) (Exhibit 1024);
- Martyn Williams, Sony unwraps high-tech 'healing' ball, CNN.com, published March 28, 2002, http://edition.cnn.com/2002/TECH/ptech/03/28/robodex.healing.ball.idg/?related, retreived on April 4, 2017 (Exhibit 1025);
- US Patent No. 5,676,582 to Lin (Exhibit 1026);
- Randall Munroe, New Pet, http://xkcd.com/413/, Retrieved from Internet Archive (http://web.archive.org/web/20080701080435/http://xkcd.com/413/) (2008), Retrieved on April 13, 2017 (Exhibit 1027);
- Hiroyuki Fujita, A Decade of MEMS and its Future, Proceedings IEEE The Tenth Annual International Workshop on Micro Electro Mechanical Systems (1997) (Exhibit 1030); and
- Gene F. Franklin, J. David Powell, Abbas Emami-Naeini, Feedback Control of Dynamic Systems, Fourth Edition, Prentice Hall (2002) (Exhibit 1031).

A. Background and Qualifications

3. My credentials are set forth in full detail in my *Curriculum Vitae* which is attached as Exhibit 1013 to this report and summarized as follows: I am currently the division CEO for Delta Five Systems. I hold the rank of Adjunct Associate Professor at Duke University and at North Carolina State University.

4. I received a Bachelor of Science in Mechanical Engineering from the University of Virginia in 1990; a Masters of Integrated Manufacturing Systems from the Integrated Manufacturing Systems Engineering Institute at North Carolina State

University in 1994; and a PhD in Electrical and Computer Engineering from North Carolina State University in 1998.

5. Since 1991, I have been active in the robotics and automation field. I have authored numerous publications and have co-authored a textbook entitled *Computational Intelligence*.

6. I have designed, built, and marketed robots, automated systems, and components thereof, including ground mobile robots, unmanned aerial vehicles (UAV), automated storage and retrieval systems (ASRS), submersible mobile robots, and proof-of-concept extra-terrestrial robots.

7. I have taught the following courses: Introduction to Robotics and Automation (Duke and NCSU); Introduction to Control Theory (Duke and NCSU); Distributed Real-Time Controls (NCSU); and myriad independent studies courses in the areas of robotics, automation, artificial intelligence, autonomy and control systems. I have also served on several MS- and PhD-level graduate student committees, designed qualifying exam problems, served on the NCSU IMSEI Board, and participated in curriculum development for undergraduate and graduate level programs.

8. I have also started and/or advised multiple champion student teams for international robot competitions including, but not limited to, the NASA/ASCE Extra-Terrestrial Robotics Competition, the DARPA Grand Challenge, the

AUVSI/ONR Autonomous Underwater Vehicle Competition, and the European CLAWAR Wall-Climbing Robot competition.

9. I have initiated multiple unmanned aerial vehicle (UAV) projects at both academic and industry levels. Academic UAVs include, but are not limited to, Quadcopters with Hybrid Remote and Autonomous Control, Marsupial UAVs that Deploy and Recover Unmanned Ground Vehicles, and Wall-Climbing UAVs. Additionally, the AngelFish Cross-Domain Submersible UAV, a DARPA ASW program that I initiated at Teledyne, included a partnership with North Carolina State University.

10. In 1999, while I was employed by Nekton Research ("Nekton"), I captured and managed multiple programs sponsored by the Department of Defense (DoD) and private-sector companies that focused primarily on autonomous underwater vehicles (AUV), remotely operated vehicles (ROV) and indirect-fire projectiles. During my tenure, Nekton entered into a joint venture agreement with the founders of what eventually became known as Parata Systems – a pharmacy automation solutions company, which I supported launching.

11. After leaving Nekton in March 2002, I joined a then New Jersey-based company called Avionic Instruments, Inc ("Avionic"). While at Avionic, I continued developing and marketing robots and supported engineering related to various design, manufacturing, quality and assembly issues on the core aerospace

product lines. Avionic product lines include, but are not limited to, ducted fans, transformer-rectifier units (TRU), regulated TRU (RTRU), auxiliary power unit (APU) control systems, power distribution systems (PDU), frequency converters, corner clamps, and VRAM attractors/thrusters. Customers included DoD, NASA, Boeing, Sikorsky, Augusta-Westland, Dassault, and Lockheed-Martin.

12. At Avionic, I was also tasked with ruggedizing, optimizing, and commercializing a core proprietary technology called the Vortex Regenerative Air/Aqueous Movement ("VRAM"). The VRAM had several applications, including but not limited to: holding breaching charges and sensors against vertical or inverted surfaces; acting as an attractor for wall and ceiling climbing robots; acting as an attractor for submersible hull-crawling robots; filter-less vacuuming (conceptually similar to the Dyson vacuum); and robotic pick-and-place end-effector (conceptually similar to a gripper) to move articles from one location (e.g., a conveyor) to another (e.g., a collator).

13. My work with the filter-less vacuum VRAM prompted me to explore a concept related to pharmacy automation, which ultimately led to a ferris-wheel concept for rapidly dispensing pills. In mid-2003, my team conceived of two prescription pill counting mechanisms that actually benefitted from centrifugal forces and optimally exploited gravity and vacuum: an inner ring with vacuum-based apertures and an inner-bowl with vacuum-based apertures. The inner-bowl with

vacuum-based apertures was deemed most viable, was awarded two US patents, and to this day forms the basis of the RxMedic ADS™ pharmacy robot. The VRAM formed the basis of Vortex HC technologies, many of which have been licensed out to entities including, but not limited to Teledyne SeaBotix, SeaRobotics, and HDT. Both RxMedic and Vortex HC were officially spun out of Avionic in July 2004, at the date Avionic was sold to Transdigm.

14. In late 2004, soon after Avionic was sold, I, along with others from Avionic, secured funding to develop an alpha-level multi-dispenser robotic system and afforded me time to write the RxMedic business plan and raise multiple rounds of venture capital. In late 2006, RxMedic (called "APDS" until November 2006) was launched as a stand-alone, sole-focus venture. After the operational launch of RxMedic, I served as General Manager and eventually Chief Technical Officer. Through my roles at RxMedic, I oversaw the development of the RxMedic ADS robot, managed the intellectual property portfolio, coordinated sales and marketing, and provided strategic, fiscal, and operational leadership. In May 2010, J.M Smith Corporation acquired RxMedic, and in an effort to assist in the change of ownership, I served as a director of RxMedic until May 2011.

15. Also in late 2004, after Avionic was sold, I, along with others from Avionic, secured funding for Vortex HC through DoD contracts and robot sales, to continue developing the VRAM Mobile Robot Platform (VMRP – a wall-climbing

robot), the ARTEMIS AUV (a holonomic submersible robot for counter-mine and counter-obstacle operations), the submersible crawler, the nuclear-grade boiler water reactor (BWR) inspection robot, and other robot products centered around the VRAM. Some DoD programs were/are classified, for which I maintained a SECRET clearance at both the personal and facilities level, and served as the facilities security officer (FSO). In late 2006, corresponding to the full launch of RxMedic, Vortex HC technologies were largely licensed to Teledyne SeaBotix, SeaRobotics, and HDT. However, I have continued to support Vortex HC licensees and customers to-date.

16. After the sale of RxMedic, and after fulfilling my 12-month employment obligation, I joined Teledyne Technologies in Summer 2011. I served as the Senior Manager for the RTP division of Teledyne Scientific, and supported multiple DoD-sponsored robotic-focused programs. Some of these programs were/are classified, for which I maintained a personal SECRET clearance. Among these programs, were cargo unmanned ground vehicles (CUGV), squad-level autonomous unmanned ground vehicles (UGV), autonomous underwater vehicles (AUV), unmanned underwater vehicles (UUV), and a cross-domain autonomous vehicle capable of transitioning between air-, surface- and underwater-domains. Cross-domain vehicles that were evaluated, designed and prototyped included, but were not limited to, the AngelFish (later called “EagleRay”) submersible AUV for anti-submarine warfare,

and a ball-shaped robot for countermine operations on the ground, in the beach zone and in the surf zone. Sensor design, refinement and signal processing was a major component of each program. Sensors employed include, but are not limited to: proximity sensors; ranging sensors; electro-optical imaging; long-, short- and mid-wave infrared (IR); inertial measurement units (IMU); optical flow; and radio-frequency (RF). Additionally, control systems were designed, refined and integrated into the aforementioned systems. Most control systems were closed-loop, in that they utilized sensor-based feedback; others were open-loop, where states were estimated with little or no feedback.

17. In late 2013, Avionic, a Transdigm business unit at that point, requested that I return to turn around a supply-chain issue, and assume management of its Sikorsky S97 Raider helicopter program. The S97 Raider is purported to be the fastest, most maneuverable helicopter, due to its coaxial, counter-rotating variable-pitch wings, and an aft-based push-propeller. Avionic also controlled two business units named Acme Aerospace (Acme) and Aerospace Cooling Solutions (ACS). Avionic, Acme and ACS supported the S97 program, which has met milestones and continues to produce multiple successful demonstrations. In 2013, Transdigm expanded my role to include directorship of the Avionic, Acme and ACS sales and marketing team, and to report operational and financial status at six-week intervals. Transdigm required that I move my family to New Jersey in late 2014, which

influenced my reluctant decision to resign and assume the CEO role of Delta Five Systems in Raleigh, NC.

18. I am being compensated in this matter at my customary rate of $375/hour. No part of my compensation depends on the outcome of this proceeding.

II. LEGAL FRAMEWORK

19. I am a technical expert and do not offer any legal opinions. However, counsel has informed me that in proceedings before the USPTO the claims of an unexpired patent are to be given their broadest reasonable interpretation in view of the specification from the perspective of one skilled in the art. The broadest reasonable interpretation does not mean the broadest possible interpretation. Rather, the meaning given to a claim term must be consistent with the ordinary and customary meaning of the term (unless the term has been given a special definition in the specification), and must be consistent with the use of the claim term in the specification and drawings. Further, the broadest reasonable interpretation of the claims must be consistent with the interpretation that those skilled in the art would reach. I have been informed that the ’920 Patent has not expired.

20. I have also been informed that the express or inherent disclosures of a prior art reference may anticipate the claimed invention. Specifically, if a person having ordinary skill in the art at the time of the invention would have known that the claimed subject matter is necessarily present in a prior art reference, then the

prior art reference may "anticipate" the claim. In other words, if the prior art necessarily functions in accordance with, or includes, the claimed limitations, it anticipates. There is no requirement that a person of ordinary skill in the art would have recognized the inherent disclosure at the time of invention, but only that the subject matter is in fact inherent in the prior art reference. Therefore, a claim is "anticipated" by the prior art if each and every limitation of the claim is found, either expressly or inherently, in a single item of prior art.

21. Counsel has also informed me that a person cannot obtain a patent on an invention if his or her invention would have been obvious to a person of ordinary skill in the art at the time the invention was made. A conclusion of obviousness may be founded upon more than a single item of prior art. In determining whether prior art references render a claim obvious, counsel has informed me that courts consider the following factors: (1) the scope and content of the prior art, (2) the differences between the prior art and the claims at issue, (3) the level of skill in the pertinent art, and (4) secondary considerations of non-obviousness. In addition, the obviousness inquiry should not be done in hindsight. Instead, the obviousness inquiry should be done through the eyes of one of skill in the relevant art at the time the patent was filed.

22. In considering whether certain prior art renders a particular patent claim obvious, counsel has informed me that courts allow a technical expert to consider

the scope and content of the prior art, including the fact that one of skill in the art would regularly look to the disclosures in patents, trade publications, journal articles, industry standards, product literature and documentation, texts describing competitive technologies, requests for comment published by standard setting organizations, and materials from industry conferences. I believe that all of the references that my opinions in this IPR are based upon are well within the range of references a person of ordinary skill in the art would consult to address the type of problems described in the Challenged Claims.

23. I understand that the United States Supreme Court's most recent statement on the standard for determining whether a patent is obvious was stated in 2007 in the KSR decision. Specifically, I understand that the existence of an explicit teaching, suggestion, or motivation to combine known elements of the prior art is a sufficient, but not a necessary, condition to a finding of obviousness. Thus, the teaching-suggestion-motivation test is not to be applied rigidly in an obviousness analysis. In determining whether the subject matter of a patent claim is obvious, neither the particular motivation nor the avowed purpose of the patentee controls. Instead, the important consideration is the objective reach of the claim. In other words, if the claim extends to what is obvious, then the claim is invalid. I further understand the obviousness analysis often necessitates consideration of the interrelated teachings of multiple patents, the effects of demands known to the

technological community or present in the marketplace, and the background knowledge possessed by a person having ordinary skill in the art. All of these issues may be considered to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent.

24. I also understand that in conducting an obviousness analysis, a precise teaching directed to the specific subject matter of the challenged claim need not be sought out because it is appropriate to take account of the inferences and creative steps that a person of ordinary skill in the art would employ. I understand that the prior art considered can be directed to any need or problem known in the field of endeavor at the time of invention and can provide a reason for combining the elements of the prior art in the manner claimed. In other words, the prior art need not be directed towards solving the same specific problem as the problem addressed by the patent. Further, the individual prior art references themselves need not all be directed towards solving the same problem. Under the KSR obviousness standard, common sense is important and should be considered. Common sense teaches that familiar items may have obvious uses beyond their primary purposes.

25. I also understand that the fact that a particular combination of prior art elements was "obvious to try" may indicate that the combination was obvious even if no one attempted the combination. If the combination was obvious to try (regardless of whether it was actually tried) or leads to anticipated success, then it is

likely the result of ordinary skill and common sense rather than innovation. I further understand that in many fields it may be that there is little discussion of obvious techniques or combinations, and it often may be the case that market demand, rather than scientific literature or knowledge, will drive the design of an invention. I understand that an invention that is a combination of prior art must do more than yield predictable results to be non-obvious.

26. I understand that for a patent claim to be obvious, the claim must be obvious to a person of ordinary skill in the art at the time of the invention. I understand that the factors to consider in determining the level of ordinary skill in the art include (1) the educational level and experience of people working in the field at the time the invention was made, (2) the types of problems faced in the art and the solutions found to those problems, and (3) the sophistication of the technology in the field.

27. I understand that at least the following rationales may support a finding of obviousness:

- Combining prior art elements according to known methods to yield predictable results;
- Simple substitution of one known element for another to obtain predictable results;
- Use of a known technique to improve similar devices (methods, or products) in the same way;
- Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;

- "Obvious to try"—choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- A predictable variation of work in the same or a different field of endeavor, which a person of ordinary skill would be able to implement;
- If, at the time of the alleged invention, there existed a known problem for which there was an obvious solution encompassed by the patent's claim;
- Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on technological incentives or other market forces if the variations would have been predictable to one of ordinary skill in the art; and/or
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior-art reference or to combine prior-art reference teachings to arrive at the claimed invention.

28. I understand that even if a *prima facie* case of obviousness is established, the final determination of obviousness must also consider "secondary considerations" if presented. In most instances, the patentee raises these secondary considerations of non-obviousness. In that context, the patentee argues an invention would not have been obvious in view of these considerations, which include: (a) commercial success of a product due to the merits of the claimed invention; (b) a long-felt, but unsatisfied need for the invention; (c) failure of others to find the solution provided by the claimed invention; (d) deliberate copying of the invention by others; (e) unexpected results achieved by the invention; (f) praise of the invention by others skilled in the art; (g) lack of independent simultaneous invention within a comparatively short space of time; (h) teaching away from the invention in the prior art.

29. I further understand that secondary considerations evidence is only relevant if the offering party establishes a connection, or nexus, between the evidence and the claimed invention. The nexus cannot be based on prior art features. The establishment of a nexus is a question of fact. While I understand that Patent Owner has not offered any secondary considerations at this time, I will supplement my opinions in the event that Patent Owner raises secondary considerations during the course of this proceeding.

III. OPINION

A. <u>Level of a Person Having Ordinary Skill in the Art</u>

30. In determining the characteristics of a hypothetical person of ordinary skill in the art of the ’920 Patent at the time of the claimed invention, which counsel has informed me is August 13, 2014, I considered several factors, including the type of problems encountered in the art, the solutions to those problems, the rapidity with which innovations are made in the field, the sophistication of the technology, and the education level of active workers in the field. I also placed myself back in the time frame of the claimed invention and considered the colleagues with whom I had worked at that time.

31. In my opinion, a person of ordinary skill in the art would have had an undergraduate degree or equivalent in physics, electrical engineering, mechanical engineering, or similar science or engineering degree, and at least two years of

industry experience (or, with a graduate degree in the above-stated fields, at least one year of experience) in designing and developing robots and associated technologies. Additional industry experience or technical training may offset less formal education, while advanced degrees or additional formal education may offset lesser levels of industry experience.

32. Based on my education, training, and professional experience in the field of the claimed invention, I am familiar with the level and abilities of a person of ordinary skill in the art at the time of the claimed invention. Additionally, I was at least a person having ordinary skill in the art as of the priority date of the '920 Patent.

B. Background of the Technology

33. By August 2014, the field of self-propelled spherical devices was extensive and well developed. Spherical, self-propelled devices have been known for well over a century. In the early 1900s, such devices were developed as toys and novelties. For example, U.S. Patent No. 933,623 to Cecil ("Cecil"), which issued on September 7, 1909, describes a mechanical toy "ball or other rotating body contain[ing an] internal mechanism which acts to rotate the ball or body." Ex.1014, *Cecil* at lines 1:8-12. The internal mechanism causes the ball "to move either in a curved path or to take a sinuous or zig-zag path" via a wound spring, clockwork, and a weight on a rotating arm. *Id.* at lines 1:18-22; *see also, id.* at lines 1:55-2:36. As

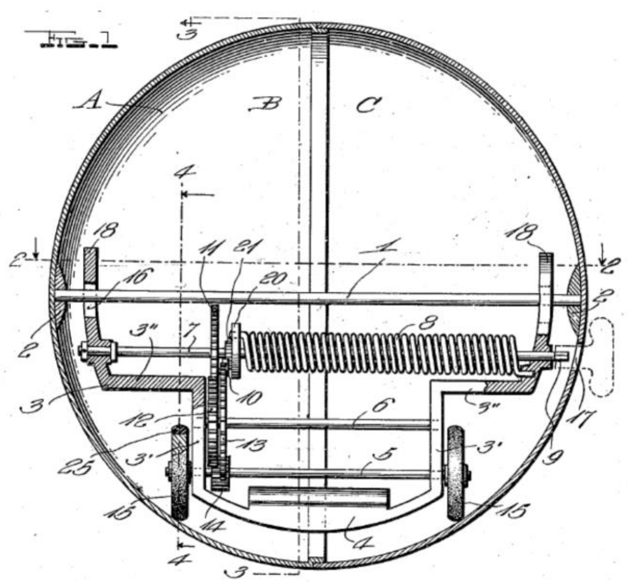
shown in the figure below, the ball "preferably support[s] a figure or other amusing device, which is balanced on the ball." *Id.* at 1:12-14.

Fig. 1

Id. at Fig. 1.

34. Similarly, U.S. Patent No. 1,263,262 to McFaul ("McFaul"), which issued on April 16, 1918, describes a self-propelled ball having an internal driving mechanism causing the ball to "propel itself in a straight line" and automatically shift itself "if it should be checked at any point in its path of travel by some obstacle." Ex.1015, *McFaul* at 1:12-27. "The driving mechanism for propelling the ball comprises a pair of wheels 15 in frictional engagement with the inner surface of the sphere." *Id.* at 1:58-61. After winding a spring, "the ball is placed upon the surface

on which it is to travel, the spring 8 will un-wind, operating the train of gears from which motion will be transmitted to the wheel 15 which in turn, owing to their frictional engagement with the inner surface of the sphere will impart a rolling motion to the same." *Id.* at 2:61-69. A cross-section of McFaul's self-propelled ball, including the mechanical drive, is shown in the figure below:



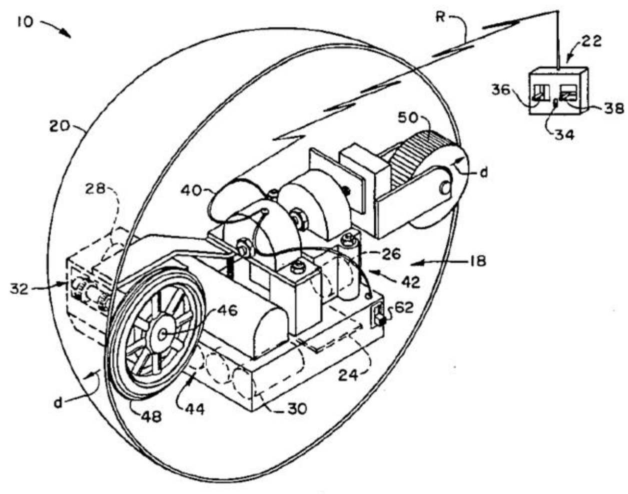
Id. at Fig. 1.

35. By at least the late 1950s to early 1960s, the drive systems of self-propelled spheres shifted from being purely mechanical to including electric motors powered by batteries. For example, U.S. Patent No. 2,949,696 to Easterling ("Easterling"), which was filed on May 21, 1957 and issued on August 23, 1960, describes "a battery propelled motorized ball which will propel itself and reverse direction when stopped by an obstruction." Ex.1016, *Easterling* at 1:15-18. Even at this early date, this design was considered advantageous because of its ability "to

provide a simple, relatively inexpensive motorized toy which can be economically made and sold and which will keep children amused for hours." *Id.* at 1:37-40.

36. By at least the early 1980s, radio-controlled vehicles were becoming more commonplace, and radio-controls were similarly incorporated into self-propelled spherical devices. For example, U.S. Patent No. 4,541,814 to Martin ("Martin"), which was filed on December 23, 1983 and issued on September 17, 1985, describes "a sphere with a radio controllable and steerable two-wheel vehicle inside having first and second wheels contracting a sphere at diametrically opposed points in the inner circumference." Ex.1017, *Martin* at 1:19-23.

37. Martin's system included a commercially available remote control transmitter 22 having control switches allowing the user to steer the vehicle within the sphere. *Id.* at 2:36-43 ("Remote control transmitter 22 may be that available commercially along with the responsive receiver 24 and steering subsystem 42 and associated power section 30 and drive subsystem 32, from Shinsei Corporation, Cerritos, Calif., as Model No. 1125 radio controlled toy jeep. The transmitter has an on-off switch 34, forward/reverse joystick type switch 36 and proportional joystick-type steering switch 38."). *Id.* at Fig. 1. As shown in the figure below, the remote controller wirelessly transmits control signals, which are received by an antenna within the sphere:



Id. at Fig. 1; *see also, id.* at 2:43-47 ("The signals are picked up by antenna 40 on the vehicle which receives them from the transmitter which in turn appropriately connects steering motor 26 and drive motor 28 with the power section 30, a battery pack, as required."). The sphere is made of "hard thermoplastic . . . or any other suitably strong, rigid material permeable by radio waves R to permit remote control." *Id.* at 2:30-34.

38. A robot is generally understood to be a mechanical device that can be programmed to perform a task under automatic control. With the development of low cost Micro Electro Mechanical Systems (MEMS) inertial sensors in the early 1990s, the development of mobile robots became a focus of academic research. Ex. 1030, *Fujita* at Figure 2 ("robot" application), Table 2 History of MEMS research topics, robot topics, p. 7 ("In terms of machine intelligence, it is possible to supply high-performance sensors and processors in large quantity and to integrate them in

machines. All the necessary functions i.e., sensing, judgment and motion, to make machines more intelligent, can be implemented in one place. An intelligent machine may have large numbers of such closed-loop MEMS embedded in it."). Researchers recognized that a spherical design offered advantages, such as increased mobility, over other mobile robot designs (e.g., wheeled robots). Ex. 1018, *Ishikawa* at 2311 ("An autonomous rolling sphere being capable of move, swing, and spin on all kinds of terrain – it has been a longstanding dream of robotics researchers. Spherical rolling is a locomotion principle that is essentially different from the other commoner ones, such as wheeled robots or walking robots. . . . In contrast, a spherical robot may have some advantages to the wheeled robots, e.g., it can move freely on the floor thanks to its complete symmetry, and is robust against uncertain terrains for its surface is smooth everywhere.").

39. As noted by Halme in 1996, "spherical construction offers extraordinary motion properties in cases where turning over or falling down are risks for the robot to continue its motion. Also it has full capability to recover from collisions with obstacles or another robots traveling in the environment." Ex.1019, *Halme* at Abstract. Halme also recognized that the omni-directional motion provided by spherical robots enhance mobility. *Id.* at 259 ("Mobility is one of the essential features of mobile robots. In many cases omni-directional motion is favoured, an example of such design is presented in [1].").

40. Spherical mobile robots having many different types of drive systems have been developed over the last few decades. Ishikawa provides a summary of the conventional types of drive systems used in spherical mobile robots as of 2010:

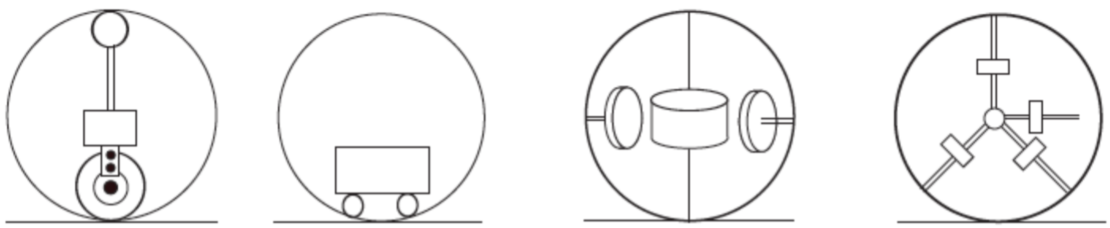
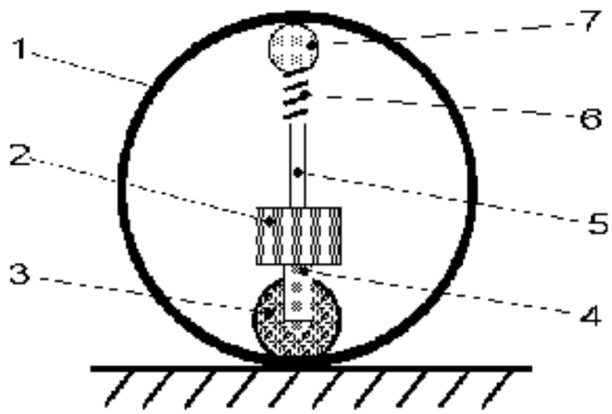
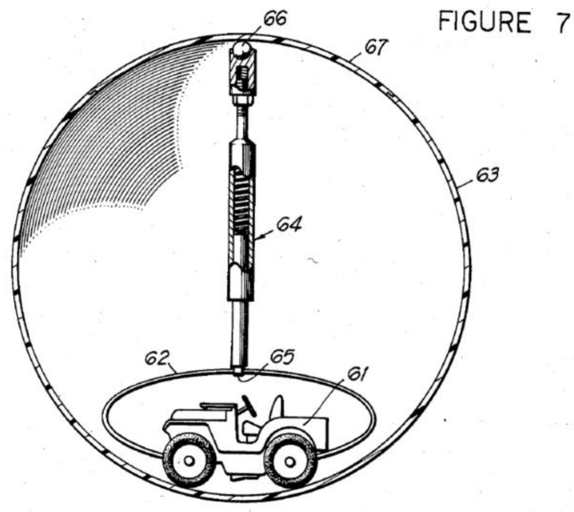


Fig. 1. Overview of conventional spherical robots

Ex. 1018, *Ishikawa* at 2311. As shown above, Halme (a) and Bicchi (b) used wheeled drives positioned on the bottom of the sphere while Bhattacharya (c) used two perpendicular rotors and Javadi (d) relied on internal weights positioned by actuators. *Id*.

41. Many of the drive systems for these spherical robots were not new, but rather were borrowed from prior non-robotic, self-propelled spherical device designs. For example, Halme's use of a wheeled drive (2, 3, 4) supporting axis (5), spring (6) and balance wheel (7) is similar to a design for a self-propelled toy ball described in U.S. Patent No. 4,601,675 to Robinson, which issued on July 22, 1986 ("Robinson):

Halme (Ex. 1019) Fig. 1	Robinson (Ex. 1020) Fig. 7
	

42. Instead, researchers primarily focused on the development of control systems used to automatically control the motion of spherical mobile robots. The fundamental features of any control system include the controller, the system to be controlled (referred to as the plant), the actuator(s) associated with the plant that responds to command signals in order to modify the plant's behavior, and the sensor(s) that describes the plant's behavior through output signals. Generally, a controller causes a system variable (e.g., speed) to adhere to a particular value, which is called the reference value. The difference between the reference value and the sensor values is called the "error." The controller inputs an actuating signal, corresponding to the error value, to the plant via the plant's actuator.

43. Several well-known types of control systems have been used to control the motion of spherical robots. As documented by Ishikawa, for example, the

spherical mobile robots developed by Halme, Bhattacharya and Javadi all utilized open-loop control systems while Bicchi utilized a closed loop control system:

author	Halme et al 1996	Bicchi et al 1997	Bhattacharya et al 2000	Javadi et al 2002
Driving Mechanism	Single Wheel	Car	Attached Rotor	Internal Weight
Input	1	2	2	4
Behavior	Kinematic	Kinematic	Kinematic	Kinematic
control	Open Loop	Closed Loop	Open Loop	Open Loop
planning	no planning	kinematic planning	dynamic planning	kinematic planning

TABLE I
COMPARISON OF SPHERICAL ROBOTS IN PREVIOUS WORKS

Ex. 1018, *Ishikawa* at 2311.

44. The study of open loop and closed loop (i.e., feedback) controllers began hundreds of years ago. Ex. 1031, *Franklin* at 12-15. An open loop controller provides an actuating signal corresponding to a reference value to the plant, but does not measure the output describing the plant's behavior. *Id.* at p. 17 ("In **open-loop control** the system does *not* measure the output and there is no correction of the actuating signal to make that output conform to the reference signal.") (emphasis in original). Therefore, there is no correction of the actuating signal to make the plant's output conform to the reference value. *Id.*

45. In contrast, a closed loop controller, which is also called a feedback controller, determines the plant's output behavior via the sensor and uses feedback

of the sensed value to influence the actuating signals produced by the controller. *Id.* at p. 17 ("In **closed-loop control** the system includes a sensor to measure the output and uses **feedback** of the sensed value to influence the control variable.") (emphasis in original). Liu, for example, describes a spherical mobile robot including feedback controller to control the robot's rolling speed by regulating the drive motor's velocity in accordance with a sensed rotational velocity. Ex. 1021, *Liu* at Abstract ("BYQ-III is a spherical mobile robot. This paper deals with the problem of its simple motion control in a fixed motion mode."), p. 965 ("Another PI (proportional-integral) controller is designed for the rolling speed in the median sagittal plane."), p. 967 ("[W]e could assume that the rolling speed of the robot can be controlled directly by regulating the drive motor's velocity.").

46. A mobile robot may be programmed to follow a planned trajectory, and/or it may be operable to perform commands received from a user. For example, Ghariblu describes a spherical mobile robot including a wireless receiver for receiving desired path data or manual inputs from a remote control transmitter operated by a user. Ex. 1022, *Ghariblu* at Abstract ("This paper deals with the construction and dynamics of a spherical mobile robot."), pp. 3-4 ("The other part is a remote controller with wireless transmitter. This controller has an interface with PC to get the robot path and programs. Meanwhile, it can send the speed of the

motors to trace the desired path. Moreover, using the keypad on it, the operator can override the motors speed.”).

47. Voice control features have also been implemented in mobile robots in order to make them more easily operated by laypersons. In 2008, Lv suggested implementing voice commands on mobile robots in order to make them “easily operated by [a] human operator, who has limited knowledge about robots or computers.” Ex. 1023, *Lv* at 2490. Lv developed a voice command control system for a mobile robot that could receive a voice command, such as “go forward,” “go backward,” “turn left,” “turn right,” etc., from the user, recognize it, and perform an associated output action. *Id.* at 2492 (Fig. 6), 2493 (Tables I and II).

48. There has also been prior development in giving spherical robots socially interactive and anthropomorphic features in order to facilitate emotional connections between humans and robots. In 2002, Sony announced a spherical mobile robot called “Q-Taro” that was able to “communicate with people through light, sound and motion by using a variety of sensors.” Ex. 1024, *Zhan* at 4921. “Sony said the device was developed to foster an emotional connection between humans and robot technology. The infrared sensors can detect the presence of a person and bring the Q-Taro to life while audio sensors enable it to roll around the floor in time to music. The glowing lights can help it show ‘emotions,’ said Mina Naito, spokeswoman for Sony.” Ex. 1025, *Williams*. Q-Taro also included voice

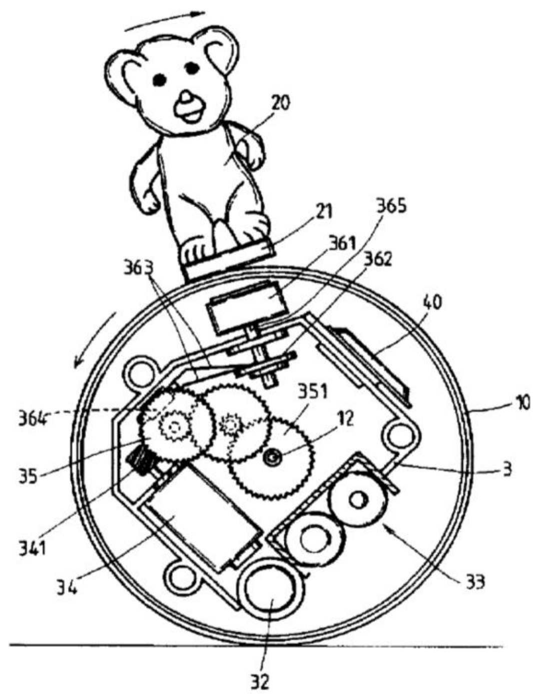
recognition technology that allowed it to recognize and react to up to ten different words. *Id*.

49. The concept of coupling objects to the outer surface of a self-propelled sphere was also a well-known concept. The Cecil patent, which as described above issued over a century ago, describes a self-propelled "ball preferably supporting a figure or other amusing device, which is balanced upon the ball." Ex. 1014, *Cecil* at 1:8-14; *see also, id.* at Fig. 1.

50. Utilizing magnetic coupling to adhere an object to the external surface of a self-propelled sphere was also well known. For example, US Patent No. 5,676,582 to Lin, which issued in October 1997, describes a rolling toy including a motor within a sphere body and first and second magnetic elements. Ex. 1026, *Lin* at Abstract ("A rolling toy includes a sphere body composed of two parts between which a axle is connected, a frame disposed in the sphere body and having a motor disposed thereto . . . including a switch element and a first magnetic element, a weight disposed to the frame and located opposite to the first magnetic element, a second magnetic element magnetically adhered to an outer surface of the sphere body and magnetically lifting the first magnetic element . . . ."). The second magnetic element 21, which is attached to a toy bear 20, is magnetically adhered to the external surface of the sphere via an interaction with the first magnetic element 361, which is located within the sphere:

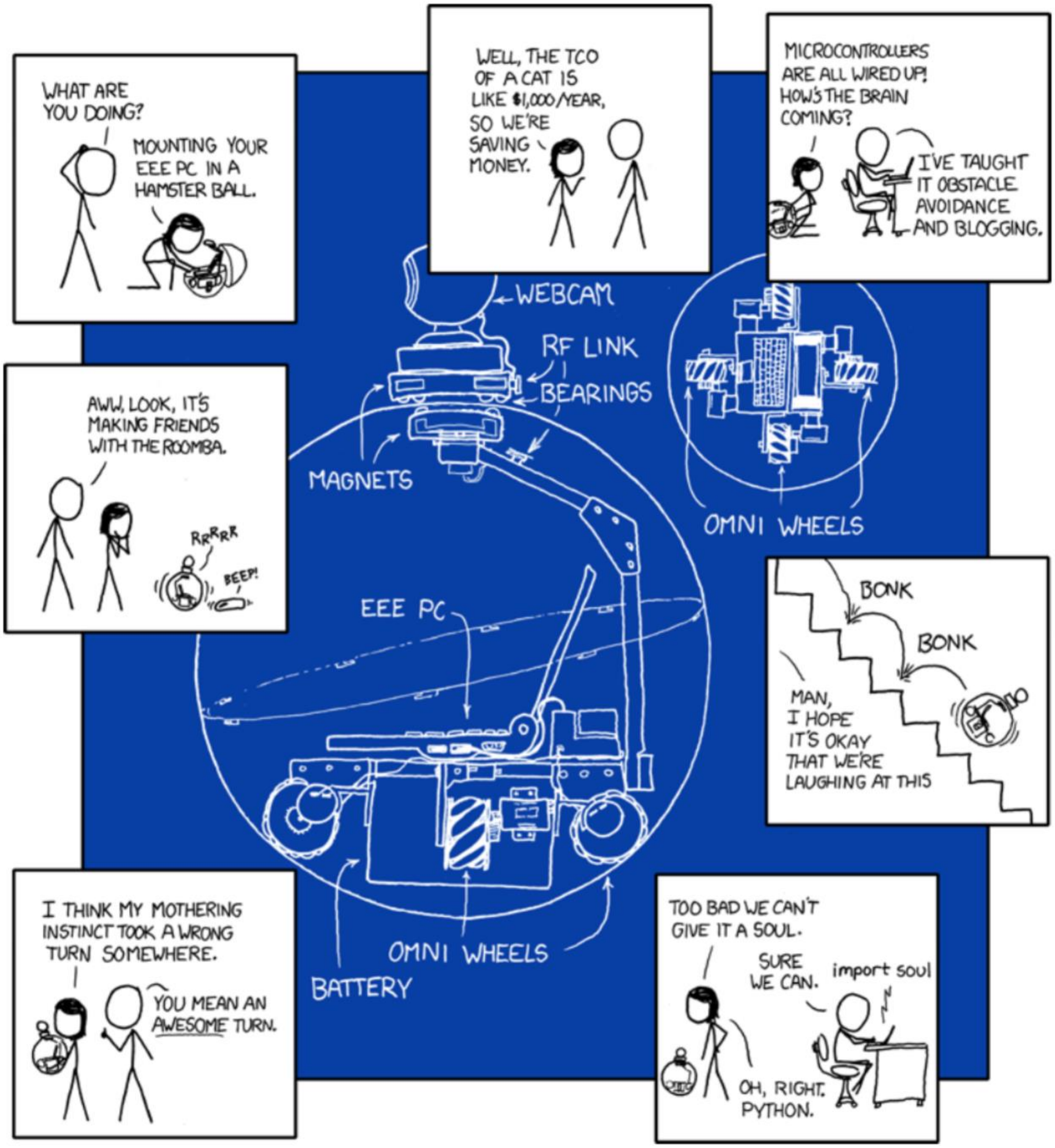
> A second magnetic element 21 is provided at an outer surface of the sphere body 10 and the second magnetic element 21 has a toy bear 20 connected thereto. The second magnetic element 21 is magnetically adhered to the sphere body 10 by the first magnetic element 361 so as to magnetically lift the first magnetic element 361 to contact the actuating plates 363 by the two disks 362 thus engaging the switch element 364 and actuating the motor 34.

Id. at 2:52-59.



Id. at Fig. 5. The second magnetic element 21 and the bear 20 "will maintain the upper position when the sphere body 10 is rolling." *Id.* at 2:67-3:2.

51. This concept was also demonstrated in the xkcd comic strip by Randall Munroe entitled "New Pet," which published in 2008:



Ex. 1027, *Munroe*. As demonstrated in the schematic drawing above, an external webcam is adhered to the external surface of the spherical robot using magnets positioned in the base of the webcam and within the sphere. *Id*.

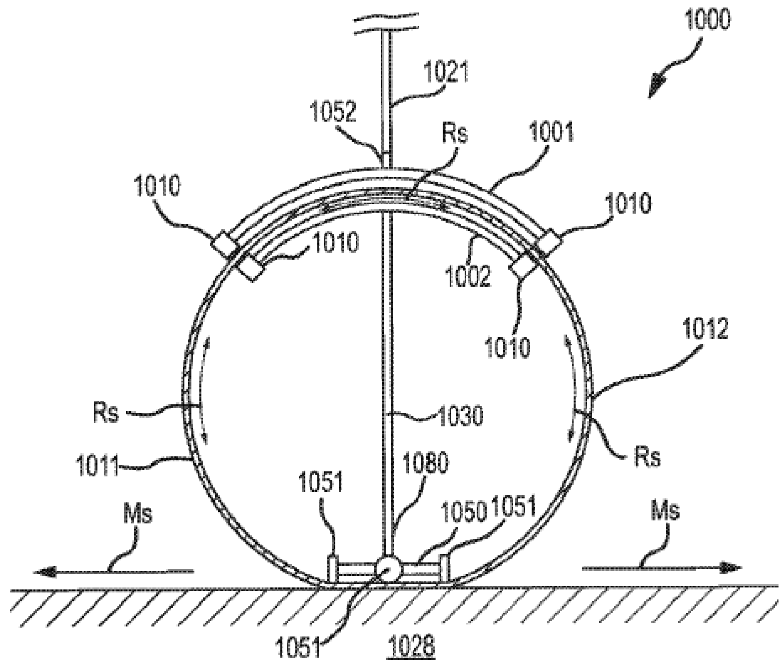
C. Angular Displacement of Smoot's Support Beam

52. Claim 1 of the '920 Patent recites the limitation "wherein the drive system, in maneuvering the spherical housing, causes the internal component to angularly displace relative to a vertical axis of the spherical housing." Ex. 1001 at Claim 1. I have been asked to analyze U.S. Patent No. 8,269,447 to Smoot (Ex. 1009) and determine whether or not it inherently discloses this claim limitation. Specifically, I have been asked to evaluate whether or not the locomotive driver 1050 as shown in Figure 10 of Smoot necessarily causes the support beam 1030 to angularly displace relative to the vertical axis of the spherical housing when the locomotive driver 1050 maneuvers the spherical housing.

53. Smoot discloses an internal drive unit (IDU) for controlling the rotation of both a sphere and a second structure that is external to the sphere. Ex. 1009, *Smoot* at 1:6-9 ("The present invention relates, generally, to a robotic drive system. Specifically, the present invention relates to a robotic system having a drive in contact with a sphere such that the drive is operable to control rotation of the sphere."), 16:58-65 ("In this regard, the exterior drive 1001 may magnetically interact with the interior drive 1002 to maintain a relative position with each other on opposite sides of a sphere sidewall 1012. Additionally, the interior drive 1002 may have extending from it a support beam 1030. On the opposite end of the support beam 1030 from the interior drive 1002 may be a locomotive driver 1050."), Fig. 10.

54. Smoot presents a variety of internal drive trains, including holonomic drive trains that operate generally in the lower half of the sphere. *Id.* at 16:65-66 ("The locomotive driver 1050 may rest on and be supported by the surface 1028."), 17:16-20 ("Alternatively, the locomotive driver 1050 may also be holonomic (i.e., the drive 1050 may employ multidirectional wheels 1051) and it may have a design similar to the drives 200, 300, or 400 (referenced in FIG. 2, FIG. 3 and FIG. 4, respectively)."), Figs. 2-4, 10.

55. Smoot also presents a support beam 1030 that is attached to and, thus, moves with the IDU and extends diametrically to the opposite surface inside the sphere. *Id.* at Fig. 10. The support beam is coupled to an internal structure 1002 containing magnets that pull an exterior structure 1001 to the sphere's external surface. *Id.* at 16:58-63 ("In this regard, the exterior drive 1001 may magnetically interact with the interior drive 1002 to maintain a relative position with each other on opposite sides of a sphere sidewall 1012. Additionally, the interior drive 1002 may have extending from it a support beam 1030."). The internal and external structures are shown to utilize friction-minimizing components including wheels 1010:



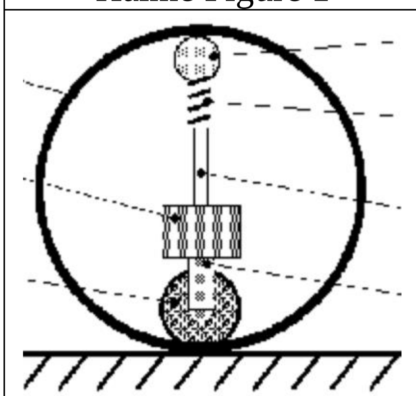
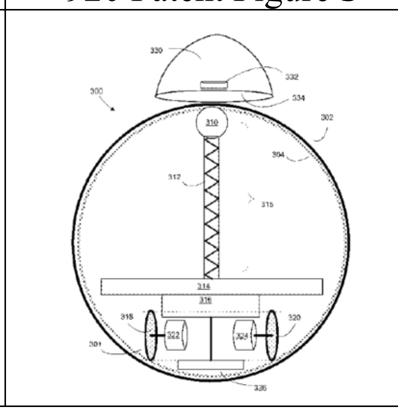
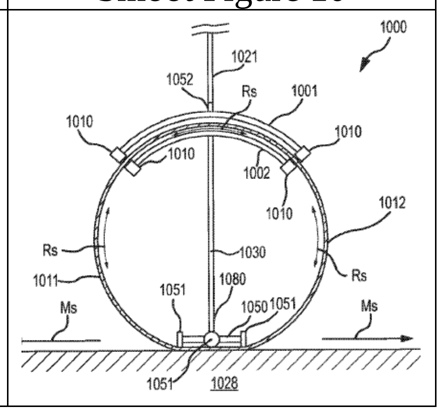
Id. at Fig. 10.

56. As shown in my analysis below, the angular displacement of the support beam 1030 relative to the vertical axis of the spherical housing is a function of the acceleration of locomotive driver 1050. This means that acceleration of locomotive driver 1050 causes the support beam 1030 to angularly displace relative to the vertical axis of the spherical housing. Therefore, Smoot inherently discloses the limitation "wherein the drive system, in maneuvering the spherical housing, causes the internal component to angularly displace relative to a vertical axis of the spherical housing."

57. Also, since the interior structure 1002 is directly coupled to the support beam 1030, angular displacement of the support beam would also cause the interior drive/support/structure 1002 to angularly displace relative to the vertical axis of the

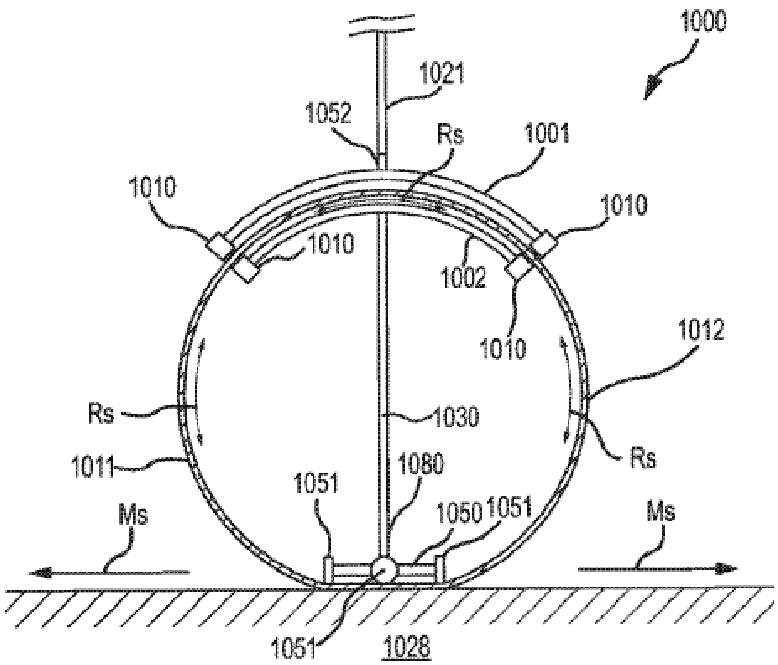
sphere. Further, the magnetic coupling between the interior structure 1002 and exterior structure 1001 would ensure that the exterior support is maintained in a relative position with respect to the interior drive on the exterior surface of the sphere as the support beam and interior support are angularly displaced by the IDU 1050.

58. Halme (Ex. 1019) provides kinematic and dynamic models of a spherical mobile robot having an internal configuration that is highly similar to the spherical devices of both Smoot and the ’920 Patent. As shown in the figures below, each of Halme, the ’920 Patent, and Smoot includes an IDU having motor-driven wheel(s) in contact with the bottom, interior surface of the sphere. The rotation of the wheel(s) causes the IDU to climb the sidewall of the sphere creating an imbalance of the center of mass. This imbalance causes the sphere to move. Halme, the ’920 Patent, and Smoot also all include an internal member attached to the IDU that extends diametrically to the opposite internal surface of the sphere:

Halme Figure 1	‘920 Patent Figure 3	Smoot Figure 10
		

59. Given the similarities between the internal configurations of Halme and Smoot, the kinematic and dynamic models of motion developed by Halme also apply to the Smoot. Therefore, I have used Halme's model foundation to support my analysis of Smoot below.

60. When Smoot's sphere is at rest, the IDU 1050 is balanced in the center of the sphere and the support beam 1030 is aligned with the vertical axis of the sphere as depicted in Figure 10:



Ex. 1009, *Smoot* at Fig. 10. However, when the IDU accelerates from rest, for example, the IDU initiates motion of the sphere (denoted above as Ms) by driving along the sphere's interior surface, moving away from the valley, and ascending the inner wall, the system's internal mass is shifted off-center, which causes the sphere

to roll because the mass is eccentric. Halme illustrates this phenomenon in the following figure:

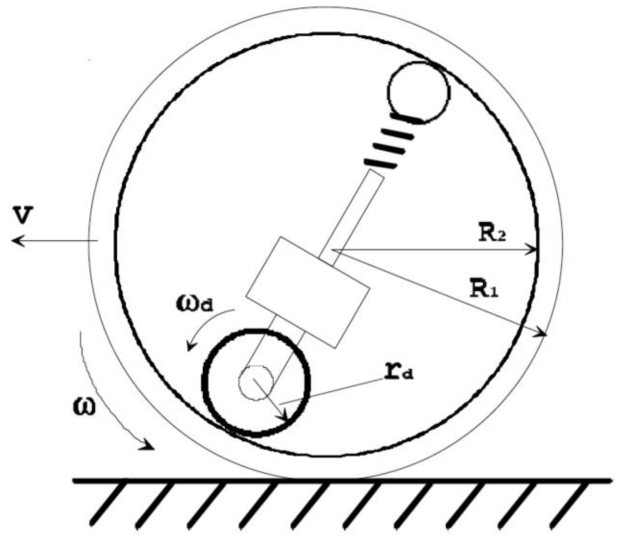


Fig. 3. Modeling of the Robot. R_1 is the external radius of the ball, R_2 is the internal radius of the ball, r_d is the radius of the driving wheel, ω_d is the angle speed of the driving wheel, ω is the angle speed of the ball,v is the forward speed of the robot.

Ex. 1019, *Halme* at Fig. 3; *see also, id.* at Fig. 4.

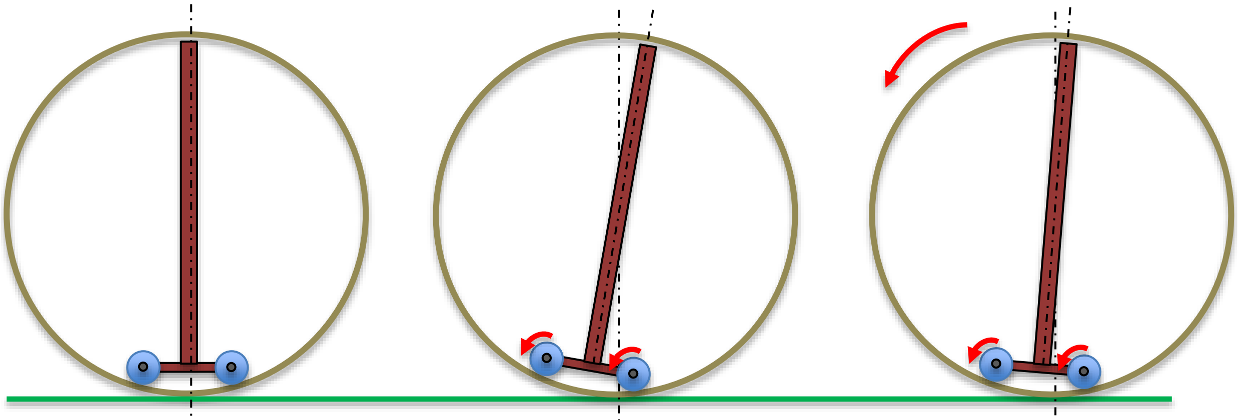
61. While Smoot does not include a figure depicting this phenomenon, Smoot's IDU would nevertheless also ascend the inner wall of the sphere when accelerating due to the effects of hysteresis that cause the motion of the sphere to lag the sphere motion of the IDU. Newtonian physics dictate that forces have a cause and effect between interacting bodies. While Newton's 3rd Law states that for every action (force) in nature there is an equal and opposite reaction, forces, such as those created by the IDU driving against the sphere's stability point, are never actually

speed-of-light step functions. Said differently, like most real-world systems, the IDU is incapable of *instantaneously* forcing the sphere to move.

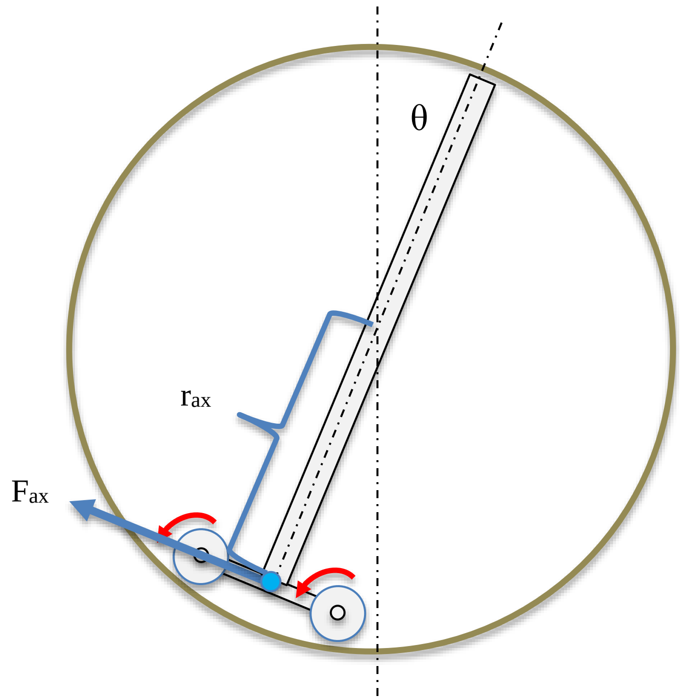
62. This is partly because the materials in components such as the wheels, gears, motors, shafts, and electronics are often deformable, impure, loose, misaligned, and impedance-prone. Furthermore, properties such as friction impede force transmission, typically in a non-linear way as static friction gives way to kinetic (and vice versa). Additionally, the inertia of the sphere itself resists movement. These cause lags. For example, drive shafts may distort from torsion before fully transferring energy to motion. Gears may need to overcome gaps between their respective teeth before they can be engaged. Gear teeth may deform before transferring energy to motion. The internal strains of the IDU wheel(s) may take some time to overcome initial deformities before fully transferring energy to motion.

63. One need only notice that a car, aircraft or boat does not instantaneously move when the throttle changes. For similar reasons, the sphere's motion will lag the IDU. In fact, the most convincing evidence of a lag stems from the fact that the sphere moves at all. Specifically, the IDU must ascend the concave surface inside the sphere so as to cause the resulting pendulous weight to move the sphere. If the IDU could not ascend, the mass would not become eccentric and, in turn, the sphere would not move. Thus, the IDU ascends the sphere's interior, causing the IDU to

pitch up and, because it is physically attached to the IDU, causing the support beam to become angularly displaced.



64. The angular displacement of Smoot's support beam 1030 can be expressed as a function of the acceleration of the IDU 1050. The IDU drive wheels impose a force, F_{ax}, on the support beam 1030 at a point where the axel of the drive wheels intersect the support beam. This intersection point is a distance, r_{ax}, from the geometric center of the sphere. Because the IDU and support beam are constrained within the sphere, the sphere's geometric center is also the axis of rotation for the support beam 1030. The torque imposed by the IDU drive wheels on the support beam is, thus, $\tau_{IDU} = F_{ax}\, r_{ax}$.

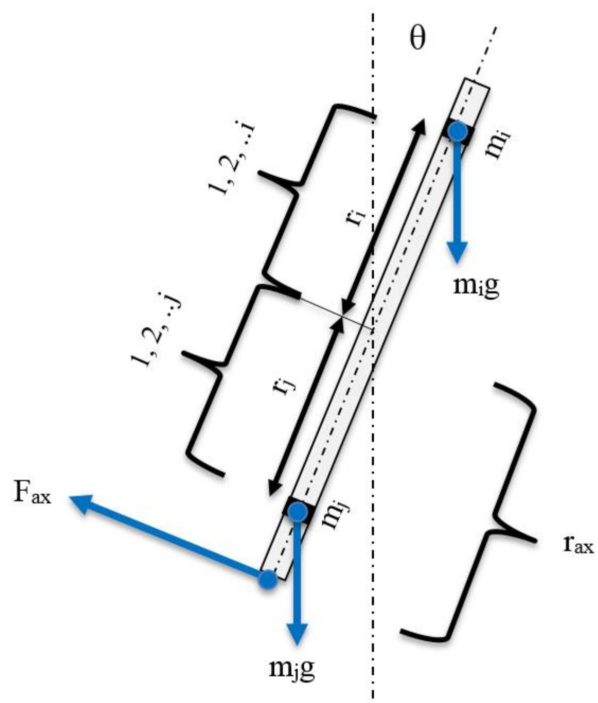


65. Because the support beam has mass, the torque induced by the IDU drive wheels causes the support beam to rotate at an angular acceleration, α_{beam}, per the relationship, $\tau_{IDU} = I_{IDU}\,\alpha_{beam}$.. The tangential acceleration is, $a_{rx} = \alpha_{beam}\, r_{ax}$,

66. *Static-to-Dynamic Transition Model*: The correlation between a_{rx} and displacement angle θ can be evaluted on the basis of a static torque model, i.e., where $\sum\tau = 0$ at the instant the system is transitioning to a dynamic model, i.e., elements are put in motion. Such a transition can be represented by a minute change in an input, Δa_{rx} and a corresponding observed output, Δθ at the boundary.

67. Smoot discloses that the interior structure positioned at the top of the support beam/IDU structure "may comprise rollers, gimbaled rollers, castored

rollers, ball bearing rollers or any other appropriate mechanism or structure . . . allowing for low friction movement of the sphere with respect to the respective structure." Ex. 1009, *Smoot* at 16:19-25. Therefore, my analysis assumes negligible friction between the top of the internal structure and the upper sphere interior. My analysis also ignores the reaction force between the lower sphere interior and the bottom of the IDU. The relevant forces on a rotatable IDU-support beam structure are described in the figure below:



68. Also shown above are distribution of mass elements relative to the geometrically-centered axis of rotation and distribution of mass elements relative to the vertical axis passing through the geometric center. Mass elements m_i are on the right side of the vertical axis, and mass elements m_j are on the left side of the vertical

axis. Mass elements, m_i include the interior and exterior structures positioned at the top of the support beam. Similarly, mass elements m_j include the IDU. Mass elements on each side of the geometrically-centered vertical axis are driven by gravity, so when the support beam rotates, the mass elements cause torque due to their respective weights at their corresponding radii, r_i or r_j.

69. For a condition where the IDU-support beam structure is transitioning from static to dynamic,

$$\sum \tau = 0: \quad \boldsymbol{F_{ax}} \cdot \boldsymbol{r_{ax}} + g \,\mathbf{sin}\, \boldsymbol{\theta}(\sum_i \boldsymbol{m_i r_i} - \sum_j \boldsymbol{m_j r_j}) = 0$$

and for τ_{IDU} = $F_{ax}\, r_{ax..}$= $I_{IDU}\, \alpha_{beam,}$

$$\boldsymbol{\tau_{IDU}} = \frac{\boldsymbol{I_{IDU}} \cdot \boldsymbol{a_{ax}}}{\boldsymbol{r_{ax}}}$$

Substituting,

$$\sum \tau = 0: \quad \frac{\boldsymbol{I_{IDU}} \cdot \boldsymbol{a_{ax}}}{\boldsymbol{r_{ax}}} + g \,\mathbf{sin}\, \boldsymbol{\theta}(\sum_i \boldsymbol{m_i r_i} - \sum_j \boldsymbol{m_j r_j}) = 0$$

Rearranging, and recognizing that only a_{rx} and θ are variables, while g, I_{IDU}, r_{ax}, r_i, r_j, m_i, and m_j are all constants,

$$\mathbf{sin}\, \boldsymbol{\theta} = \frac{-\boldsymbol{I_{IDU}} \cdot \boldsymbol{a_{ax}}}{g \boldsymbol{r_{ax}}(\sum_i \boldsymbol{m_i r_i} - \sum_j \boldsymbol{m_j r_j})}$$

or, when the support beam is vertical,

$$\boldsymbol{\theta} = \sin^{-1}\left[\frac{-\boldsymbol{I}_{IDU} \cdot \boldsymbol{a}_{ax}}{g\boldsymbol{r}_{ax}(\sum_i \boldsymbol{m}_i\boldsymbol{r}_i - \sum_j \boldsymbol{m}_j\boldsymbol{r}_j)}\right]$$

It can be seen from the above derivation that when the support beam is vertical and not accelerating, i.e., a_{rx} = 0, that θ = 0, as well. If a minute change is applied to acclerate a_{rx} we can see the correlating angular displacement from:

$$\Delta\boldsymbol{\theta} = \sin^{-1}\left[\frac{-\boldsymbol{I}_{IDU} \cdot \Delta\boldsymbol{a}_{ax}}{g\boldsymbol{r}_{ax}(\sum_i \boldsymbol{m}_i\boldsymbol{r}_i - \sum_j \boldsymbol{m}_j\boldsymbol{r}_j)}\right]$$

This derivation of the static-to-dynamic transition shows that a change in IDU acceleration corresponds to an angular displacement of the support beam. In other words, Smoot's IDU 1050 causes the support beam 1030 to angularly displace relative to the vertical axis of the spherical housing when the IDU accelerates from rest.

70. *Dynamic Model:* I have also developed a dynamic model showing the relationship between IDU acceleration and the angular displacement of the support beam when the system is in motion. As shown in the analysis below, variations in the IDU acceleration cause variations in the displacement of the support beam.

71. Since $\tau_{IDU} = \tau_{IDU}$, we can relate the inertial moment of the to the IDU's acceleration with:

$$\boldsymbol{I}_{IDU} = \frac{\boldsymbol{F}_{ax} \cdot \boldsymbol{r}_{ax}}{\boldsymbol{\alpha}_{beam}}$$

72. And, because tangential acceleration, $a_{rx} = \alpha_{beam}\, r_{ax}$,

$$I_{IDU} = \frac{F_{ax} \cdot r_{ax}^2}{a_{ax}}$$

73. Halme provides the foundation for the inertial moment of the support beam and attached IDU, as shown in the figure below, by accounting for the distribution of mass elements relative to the geometrically-centered axis of rotation, and the distribution of mass elements relative to the vertical axis passing through the geometric center. For example, mass elements m_i are on the right side of the vertical axis, and mass elements m_j are on the left side of the vertical axis:

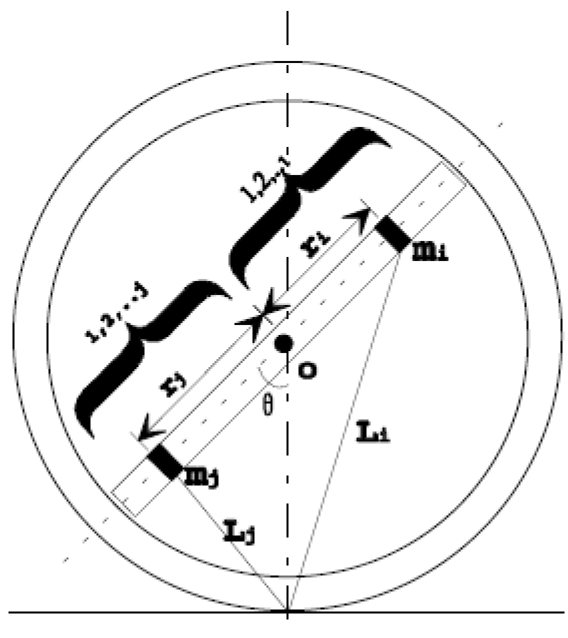


Fig. 6. Calculation of the inertial moment of the Inside Drive Unit.

Ex. 1019, *Halme* at Fig. 6.

74. As discussed above, mass elements, m_i include the interior and exterior structures positioned at the top of the support beam. Similarly, mass elements m_j include the IDU. Mass elements on each side of the geometrically-centered vertical axis are driven by gravity, so when the support beam rotates, the mass elements cause torque due to their respective weights at their corresponding radii, r_i or r_j. R_1 is the external radius of the sphere. The support beam inertially resists torque, be it from these distributed mass elements or from the IDU drive wheel forces according to the following derivation:

$$I_{IDU} = mR_1^2 + \sum_i m_i r_i^2 - \sum_j m_j r_j^2 + 2\cos\theta\left(\sum_i m_i r_i^2 - \sum_j m_j r_j^2\right)$$

75. Equating the inertial moments, we derive a mathematical model showing that the angular displacement is a function of IDU acceleration:

$$I_{IDU} = I_{IDU}$$

$$\frac{F_{ax} \cdot r_{ax}^2}{a_{ax}} = mR_1^2 + \sum_i m_i r_i^2 - \sum_j m_j r_j^2 + 2\cos\theta\left(\sum_i m_i r_i^2 - \sum_j m_j r_j^2\right)$$

Rearranging,

$$\theta = \cos^{-1}\left[\frac{\frac{F_{ax} \cdot r_{ax}^2}{a_{ax}} - mR_1^2 - \sum_i m_i r_i^2 + \sum_j m_j r_j^2}{2\left(\sum_i m_i r_i^2 - \sum_j m_j r_j^2\right)}\right]$$

For variations of the force-acceleration ratio, which can occur especially at transients, it can be seen that variations in acceleration cause variations in the angular displacement of the support beam.

76. It should be noted that torque from, for example, the IDU drive wheel(s) produce a counter-torque which would cause the IDU and associated support beam to rotate in a direction opposite of the IDU drive wheel(s). This concept is easily recognized by lay-persons by common examples including, but not limited to, wheelies on motorcycles, helicopters that turn opposite the rotary wing in the absence of a tail rotor, inverted pendulums that rotate opposite the cart that support them, etc. Typically, rotations and counter-rotations of systems in free-space occur relative to a common axis. Constrained counter-torque is the result of the IDU and support beam system being contained in within, for example, the sphere. In this case, the wheels may rotate about one axis, but the support beam is forced to rotate about an axis through the center of the sphere. This means that the two axes may be different, but still parallel to each other. In general, the rotation and counter-rotation are the result of inertial forces, even if they axes of rotation are not common.

77. Alternatively, it would be obvious based on the knowledge of a person having ordinary skill in the art for the locomotive driver 1050 (i.e., drive system) to cause the support beam 1030 (i.e., internal component) to angularly displace relative to a vertical axis of the spherical body when maneuvering the sphere. A person of

ordinary skill would have an understanding of basic mechanical systems. And, for the reasons described in my analysis above, would have expected that when Smoot's IDU accelerates from rest, for example, the IDU initiates motion of the sphere by driving along the sphere's interior surface and ascending the inner wall, the IDU would pitch up causing the support beam to become angularly displaced. For the reasons discussed above, a skilled artisan would also expect the angular displacement of the support beam to be a function of the acceleration of the IDU.

D. <u>Smoot Applied to Claim 3</u>

78. Claim 3 of the '920 Patent recites the limitation "wherein the one or more magnetic components of the self-propelled device include at least two magnets that are dispersed within the spherical housing to stabilize the accessory device." Ex. 1001 at Claim 3. I have been asked to analyze Smoot (Ex. 1009) and determine whether or not it inherently discloses this claim limitation. Specifically, I have been asked to evaluate whether or not the plurality of magnets dispersed within Smoot's interior support necessarily stabilizes the exterior support.

79. Smoot's interior and exterior supports may include a plurality of magnets (720) dispersed in its chassis in order to align the internal support with the exterior support:

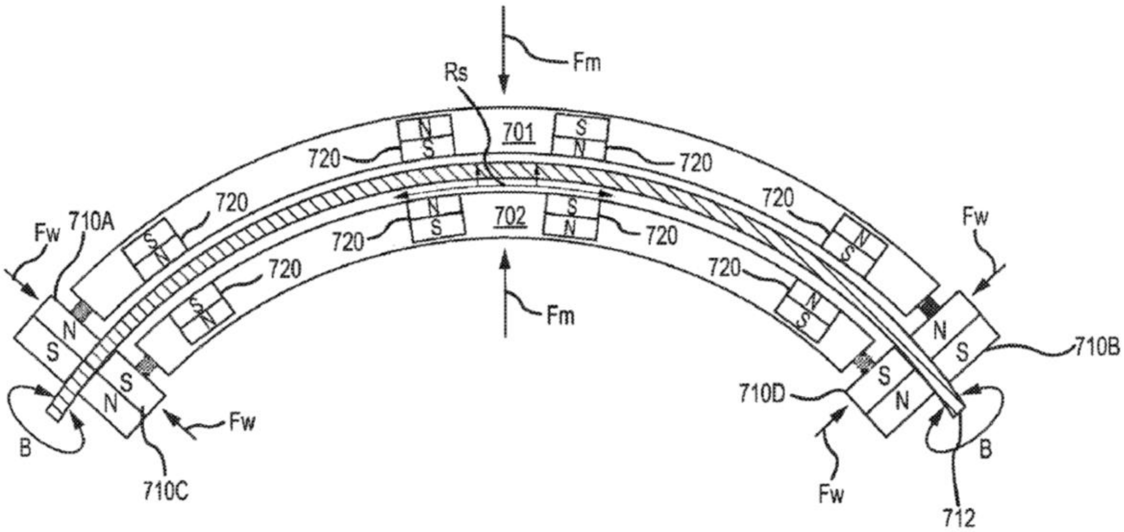


FIG.7

Ex. 1009, *Smoot* at Fig. 7.

> Further still, magnets 720 may be positioned on the chassis of the drives 701, 702 such that the arrangement of the corresponding magnets 720 on the exterior drive 701 and the interior drive 702 may align the drives 701, 702 as well as provide the urging force (Fm) to sandwich the sidewall 712 between the drives 701, 702.

Id. at 15:9-14.

80. A person of ordinary skill would have understood that aligning poles of the magnets 720 in the interior support with respective opposite poles of magnets 720 in the exterior support would create a strong magnetic coupling that would be more resistive to outside forces, such as gravity. A strong magnetic coupling would ensure that if the support beam pitches, the exterior support would pitch with the support beam as if it were attached at the end of the support beam. This would

necessarily stabilize the exterior support by making it less likely to decouple from the interior support.

81. A person of ordinary skill would also understand that the use of a plurality of magnetic couplers as shown in Figure 7 of Smoot would necessarily stabilize the orientation of the external structure with respect to the orientation of the support beam. In other words, the strong magnetic coupling between the external and interior structures would ensure that the exterior support rotates with the support beam as if it were cleated to the end of the support beam.

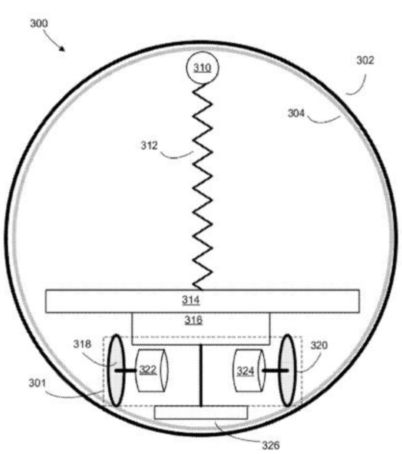
82. At the very minimum, it would have been obvious to a person having ordinary skill in the art that the plurality of magnets dispersed within Smoot's interior support would serve to stabilize the exterior support for the reasons described above. A skilled artisan would have expected Smoot's exterior support to maintain its magnetic coupling with the interior support as the device maneuvers. Therefore, it would have been obvious based on the knowledge of a person having ordinary skill in the art to include a plurality of magnets dispersed within Smoot's interior support form a strong magnetic coupling between the interior and exterior supports in order to stabilize the exterior support as described above.

E. <u>Obvious to Combine Smoot and Wilson</u>

83. I have also been asked to evaluate whether or not it would have been obvious to a person having ordinary skill in the art at the time of the '920 Patent to

combine Smoot and Wilson to meet certain limitations of the Challenged Claims.

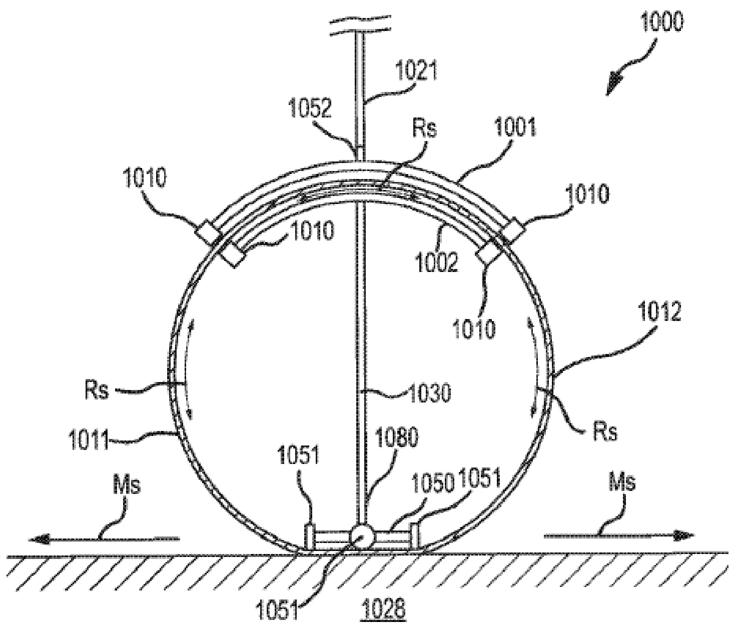
84. U.S. Patent Application Publication No. 2012/0168240 to Wilson et al. ("Wilson") also describes a self-propelled spherical device with an internal drive unit (IDU) that moves the sphere. Ex. 1010, *Wilson* at [0027] ("In an embodiment, a self-propelled device is provided, which includes a drive system, a spherical housing, and a biasing mechanism. The drive system includes one or more motors that are contained within the spherical housing. The biasing mechanism actively forces the drive system to continuously engage an interior of the spherical housing in order to cause the spherical housing to move."). As shown in the figure below, the internal configuration of Wilson's sphere is similar to that of Smoot in that the IDU is coupled to a biasing mechanism that extends upwardly from the drive unit and contacts "inner surface 304 at a point diametrically opposed to wheels 318 and 320." *Id.* at [0097].



Id. at Fig. 3.

a. <u>*Claim 1: "a controller device . . . wherein the drive system is operable under control of the controller device to cause the spherical housing to maneuver, including to roll on the underlying surface"*</u>

85. Smoot's spherical device includes an IDU with motor-driven wheels used to produce "rotation (Rs) of the sphere 1011 resulting in movement (Ms) along the surface 1028 in a desired or predefined path." Ex. 1009, *Smoot* at 17:9-23. The IDU causes the sphere to "roll along the surface 1028 under the locomotive driver 1050." *Id.* at 17:29-34.



Id. at Fig. 10.

86. Smoot's IDU has an associated internal controller that controls the motors driving the IDU's wheels. *Id.* at 17:16-20 ("Alternatively, the locomotive driver 1050 may also be holonomic (i.e., the drive 1050 may employ multidirectional wheels 1051) and it may have a design similar to the drives 200, 300, or 400

(referenced in FIG. 2, FIG. 3 and FIG. 4, respectively).”), 8:31-34 (“Additionally, a controller 210 may be provided in communication with the motors 204 such that the controller 210 may independently drive each motor 204.”); *see also, id.* at 10:20-22, 11:51-53, Figs. 2-5. The internal controller includes, among other things, a processor and a wireless communication link. *Id.* at 11:57-58 (“The controller 500 may include a processor 510.”), 12:61-64 (“Additionally, the controller 510 may include a communication link 540. The communication link 540 may comprise a wireless module (e.g., employing RF, Wi-Fi, or other appropriate wireless technology).”), Fig. 5. The wireless communication link receives control signals from an “external source” or “outside control” that are used to control operation of the IDU:

> The communication link 540 may transmit or receive data regarding the operation of the controller 510. For example, the communication link 540 may be operative to receive commands from an external source (e.g., an operator supported by a drive or elsewhere) to control the operation of a drive.

Id. at 12:64-13:2.

> The movement of the object and sphere may be accomplished by a controller or by way of outside control in communication with the controller.

Id. at 17:54-56.

87. Wilson’s self-propelled spherical device also includes an IDU with motor driven wheels that produces rotation of the sphere. Ex. 1010, *Wilson* at [0054]

("Movement and steering actuators are also referred to as a drive system or traction system. The drive system moves device 100 in rotation and translation, under control of processor 114."); [0055] ("In one embodiment, drive system actuators 126 include two parallel wheels, each mounted to an axle connected to an independently variable-speed motor through a reduction gear system."). The IDU has an associated processor that controls the motor(s). *Id.*

88. Wilson's spherical device also includes a wireless communication port, such as a Bluetooth transceiver, allowing it to receive wireless control inputs from a remote controller device operated by a user. *Id.* at [0030] ("A controller device is operable by a user to control the self-propelled device."), [0032] ("In still another embodiment, a self-propelled device includes a drive system, a wireless communication port, a memory and a processor. . . . The processor (or processors) receive one or more inputs from the controller device over the wireless communication port, map each of the one or more inputs to a command based on the set of instructions, and control the drive system using the command determined for each of the one or more inputs."); [0041] ("In one embodiment, wireless communication 110 implements the BLUETOOTH communications protocol and transducer 602 is an antenna suitable for transmission and reception of BLUETOOTH radio signals. Other wireless communication mediums and protocols may also be used in alternative implementations.").

89. The remote controller device is a computing device, such as a smartphone or a tablet. *Id.* at [0038] ("As described by various embodiments, self-propelled device 100 can be operated to move under control of another device, such as a computing device operated by a user."), [0065] ("The computing device 208 can correspond to any device comprising at least a processor and communication capability suitable for establishing at least uni-directional communications with self-propelled device 214. Examples of such devices include, without limitation: mobile computing devices (e.g., multifunctional messaging/voice communication devices such as smart phones), tablet computers, portable communication devices and personal computers."). The computing device controller receives inputs from the user via input elements such as a touchscreen or mechanical switches/buttons. *Id.* at [0121] ("More specifically, on the computing device, the program 756 can provide a user interface 760, including logic 762 for prompting and/or interpreting user input on the computing device. Various forms of input may be entered on the computing device 750, including, for example, user interaction with mechanical switches or buttons, touchscreen input, audio input, gesture input, or movements of the device in a particular manner."). The user input is interpreted by the computing device and then wirelessly transmitted to the spherical device. *Id.* at [0123] ("In some embodiments or implementations, the input generated on the computing device 750 is interpreted as a command and then signaled to the self-propelled device 710. In

other embodiments or implementations, the input entered on the computing device 750 is interpreted as a command by programmatic resources on the self-propelled device 710.").

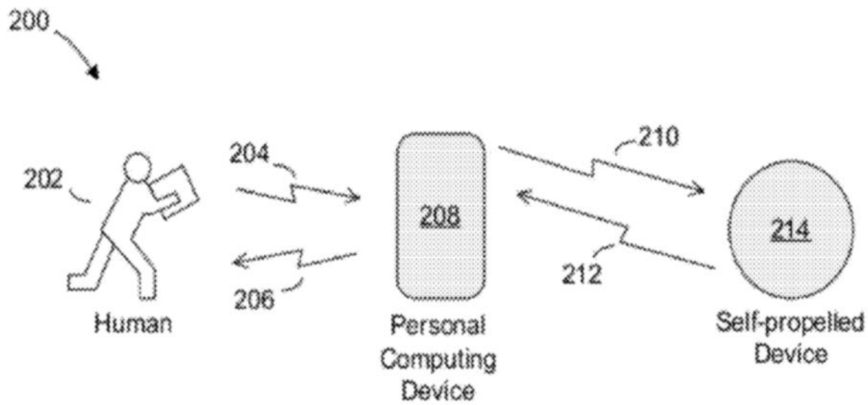


FIG. 2A

Id. at Fig. 2A.

90. The self-propelled device's processor includes software that enables it to interpret the control input received from the computing device controller and control the device's movement based on an interpretation of the input. *Id.* at [0125] ("In operation, the self-propelled device 710 implements the programmatic runtime 716A using one or more sets of program instructions stored in its program library 720. The program runtime 716A may correspond to, for example, a program selected by the user, or one that is run by default or in response to some other condition or trigger. Among other functionality, the program runtime 716A may execute a set of program-specific instructions that utilizes device functions and/or resources in order

to: (i) interpret control input from the computing device 750; (ii) control and/or state device movement based on the interpretation of the input . . . .").

91. In my opinion, it would have been obvious to a person of ordinary skill in the art to utilize Wilson's remote controller device as an external source/outside control wirelessly providing control commands to Smoot's internal controller. As I discussed above in the Background of the Technology section, remote control devices have been used to control the movement of self-propelled spherical devices for decades. *See*, ¶¶ 36-37. Therefore, using Wilson's remote controller device as the external source of command signals for Smoot's IDU would have predictably enabled an operator to control operation of the IDU and cause Smoot's spherical device to maneuver and roll on an underlying surface. Given the common and widespread use of remote control devices, a skilled artisan would have enjoyed a reasonable expectation of success incorporating Wilson's remote controller device into Smoot's system.

92. In addition, Smoot's teaching of an "external source" or "outside control" providing wireless commands to the spherical device provides an express teaching, suggestion, or motivation that would have led a skilled artisan to incorporate a remote controller, such as taught by Wilson, into the system taught by Smoot.

93. Finally, a person of ordinary skill in the art would understand that Smoot's spherical device already includes the necessary electronic components needed to receive and process wireless commands from Wilson's remote controller device (i.e., wireless communications module 540 and processor 510). Therefore, incorporating Wilson's remote controller device into Smoot's system would not require any physical modifications to Smoot's spherical device. As such, substituting Wilson's remote controller device as the "external source" of control commands in Smoot's system would not change Smoot's principle of operation or render it inoperable for its intended purpose.

b. <u>Claim 7: "a hardware component to control at least the drive system based on user interaction with the controller device</u>"

94. As I discussed above, Smoot's IDU includes an internal controller, which is a hardware component that controls the IDU based on control signals received from an "external source" or "outside control." Ex. 1009 at 12:61-13:2, 17:54-56. For the reasons discussed above with regard to Claim 1, it would have been obvious to a person having ordinary skill in the art to utilize a remote controller device, such as that taught by Wilson, as the external source used to generate and transmit control commands to Smoot's internal controller. *See*, ¶¶ 91-93.

95. As I also discussed above, Wilson teaches that the user interacts with the remote control device to generate control inputs. Ex.1010, *Wilson* at [0121] ("More specifically, on the computing device, the program 756 can provide a user

interface 760, including logic 762 for prompting and/or interpreting user input on the computing device. Various forms of input may be entered on the computing device 750, including, for example, user interaction with mechanical switches or buttons, touchscreen input, audio input, gesture input, or movements of the device in a particular manner.”). In my opinion, it would have also been obvious to enable Smoot’s internal controller to control the IDU based on commands generated by a user’s interactions with the remote controller device as taught by Wilson. Smoot already teaches that the internal controller wirelessly receives commands from an “external source” or “outside control” that are used to control operation of the IDU. Ex.1009, *Smoot* at 12:61-13:2, 17:54-56. Smoot also teaches that the “external source” may be an operator/user. *Id.* A skilled artisan would have understood that the purpose of any remote controller device, including that taught by Wilson, is to allow a user to interact with the remote controller device in order to control another device. Therefore, it would have been obvious to allow an operator to interact with a remote controller device in order to provide wireless commands to Smoot’s internal controller for controlling the IDU.

c. *Claim 8: “wherein the hardware component receives user input from the controller device that is in wireless communication with the self-propelled device, the hardware component implementing the user input to control the drive system”*

96. As I discussed above with regard to Claim 1, it would have been obvious to enable Smoot’s internal controller to receive user input from a remote controller

device, such as taught by Wilson, via wireless communication. *See*, ¶¶ 91-93. Smoot already teaches that the internal controller wirelessly receives commands from an "external source" or "outside control" that are used to control operation of the IDU. Ex. 1009, *Smoot* at 12:61-13:2, 17:54-56. Smoot also teaches that the "external source" may be an operator/user. *Id.* Therefore, it would have been obvious to a person having ordinary skill in the art to enable Smoot's internal controller to implement the operator's commands inputs to control the IDU.

d. *Claim 11: "wherein the hardware component causes the drive system to perform a feedback action in response to an event or condition"*

97. I have been informed by counsel that the broadest reasonable interpretation of this claim limitation at least includes "wherein the hardware component performs feedback control to control operation of the drive system in response to a sensed event or condition." Wilson's self-propelled device includes inertial sensors used to monitor conditions such as the self-propelled device's position and orientation:

> Sensors 112 provide information about the surrounding environment and condition to processor 114. In one embodiment, sensors 112 include inertial measurement devices, including a 3-axis gyroscope, a 3-axis accelerometer, and a 3-axis magnetometer. According to some embodiments, the sensors 114 provide input to enable processor 114 to maintain awareness of the device's orientation and/or position relative to the initial reference frame after the device initiates movement.

Ex. 1010, *Wilson* at [0042].

98. The processor in the self-propelled device uses the sensed orientation information to perform feedback control of the IDU:

> To maintain stability, the device uses feedback about its motion to compensate for the instability. Sensor input, such as provided from sensors 112 (see FIG. 1) or accelerometers or gyroscopes (see FIG. 6), can be used to detect what compensation is needed. In this way, the device maintains a state of dynamic inherent instability as it moves under control of sensors and control input, which can be communicated from another controller device.

Id. at [0102].

> When it is desired that device 500 move at a constant velocity, the technique illustrated in FIGS. 4A, 4B and 4C can be extended as shown in FIG. 5. To achieve continuous motion at a constant velocity, the displacement of center of mass 506 relative to center of rotation 502 is maintained by action of wheeled actuators 508. The displacement of the center of mass 506 relative to center of rotation 502 is difficult to measure, thus it is difficult to obtain feedback for a closed-loop controller to maintain constant velocity. However, the displacement is proportional to the angle 510 between sensor platform 504 and surface 512. The angle 510 can be sensed or estimated from a variety of sensor inputs, as described herein. Therefore, in one embodiment, the speed controller for robotic device 500 can be implemented to use angle 510 to regulate speed for wheeled actuators 508 causing device 500 to move at a constant speed across surface 512. The speed controller determines the desired angle 510 to produce the desired speed, and the desired angle setpoint is provided as an input to a closed loop controller regulating the drive mechanism.
>
> FIG. 5 illustrates use of angle measurement for speed control; however the technique can be extended to provide control of turns and rotations, with feedback of appropriate sensed angles and angular rates.

Id. at [0107]-[0108]; *see also, id.* at Fig. 5.

99. Smoot's self-propelled spherical device similarly includes an inertial measuring unit that senses position and orientation information. Ex. 1009, Smoot at 11:60-65 ("The inertial measuring unit 520 may include a plurality of sensors to determine the roll, pitch and yaw of a drive (e.g., a drive on which the controller 500 is located) as well as the pitch rate, roll rate and yaw rate of a drive. The inertial measuring unit 520 may further include sensors to monitor a position (e.g., position with respect to vertical) of a mast.").

100. In my opinion, it would have been obvious to a person having ordinary skill in the art to enable Smoot's processor to perform feedback control in order to control operation of the IDU in response to the sensed orientation information. As I discussed above in the Background of the Technology, using feedback controllers to control the motion of spherical mobile robots was known well prior to the '920 Patent. *See*, ¶¶ 43-45. Therefore, a person having ordinary skill in the art would have enjoyed a reasonable expectation of success applying well-known principles of feedback control to enable Smoot's processor to control the drive based on sensed position/orientation data.

101. Wilson recognizes that implementing feedback control would have the predictable result of compensating for instability thereby making the system's motion more stable. Wilson also discusses using feedback control to enable the spherical device to maintain a constant velocity or perform turns and rotations. A

skilled artisan would be motivated to similarly enable Smoot's internal controller to perform feedback control using sensed position/orientation data in order to control the drive and achieve stable movement, maintain a constant velocity, and/or perform turns and rotations.

e. <u>Claim 13: "a plurality of actuators which cause the spherical housing to perform an emotive action</u>"

102. I understand that Claim 14, which depends from Claim 13, allows for "an emotive action" to include "one or more of a head nod, a shake, a tremble, or a spin." Ex. 1001 at Claim 14. Wilson's self-propelled spherical device includes a plurality of actuators 126 that "cause device 100 to execute communicative or emotionally evocative movements, including emulation of human gestures, for example, <u>head nodding, shaking, trembling, spinning</u> or flipping." Ex. 1010, *Wilson* at [0056] (emphasis added).

> In one embodiment, display 118 operates in conjunction with actuators 126 to communicate information by physical movements of device 100. For example, device 100 can be made to emulate a human head nod or shake to communicate "yes" or "no."

Id. at [0047].

> Actuators 126 convert electrical energy into mechanical energy for various uses. A primary use of actuators 126 is to propel and steer self-propelled device 100. Movement and steering actuators are also referred to as a drive system or traction system. The drive system moves device 100 in rotation and translation, under control of processor 114. Examples of actuators 126 include,

> without limitation, wheels, motors, solenoids, propellers, paddle wheels and pendulums.

Id. at [0054].

> However, it should be appreciated that actuators 126, in various embodiments, produce a variety of movements in addition to merely rotating and translating device 100. In one embodiment, actuators 126 cause device 100 to execute communicative or emotionally evocative movements, including emulation of human gestures, for example, head nodding, shaking, trembling, spinning or flipping. In some embodiments, processor coordinates actuators 126 with display 118. For example, in one embodiment, processor 114 provides signals to actuators 126 and display 118 to cause device 100 to spin or tremble and simultaneously emit patterns of colored light. In one embodiment, device 100 emits light or sound patterns synchronized with movements.

Id. at [0056].

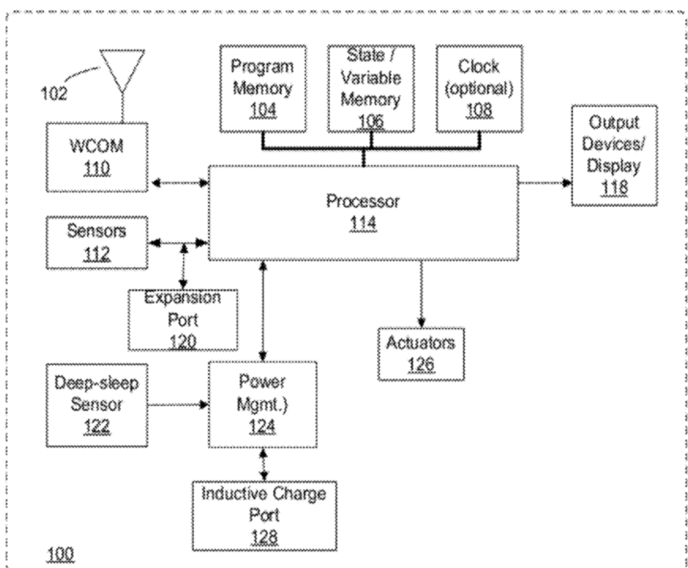


FIG. 1

Id. at Fig. 1.

103. In my opinion, it would have been obvious to a person having ordinary skill in the art to include actuators in Smoot's spherical device that enable the device to "execute communicative or emotionally evocative movements" such as a "a head nod, a shake, a tremble, or a spin" as taught by Wilson. As I discussed above, in the Background of the Technology section, enabling spherical robots to communicate "emotions" through motions in order to facilitate emotional connections between humans and robots was known since at least 2002. *See,* ¶ 48. A skilled artisan would have appreciated that enabling Smoot's device to perform emotive actions, such as those taught by Wilson, would have predictably increased the device's ability to both communicate with and form emotional connections with users.

104. Smoot envisions using the spherical device for entertainment purposes, which would involve laypersons. Ex.1009, *Smoot* at 7:10-12 ("As one representative example, the holonomic drive system 100 may be used in an entertainment application."). A skilled artisan would have reasonably expected that enabling Smoot's device to perform emotive actions, such as those taught by Wilson, would enabled the device to have more successful interactions with lay-users. As such, it would have been obvious to improve similar spherical robotic devices in the same way.

f. Claim 14: "wherein the emotive action includes one or more of a head nod, a shake, a tremble, or a spin"

105. For reasons discussed above with regard to Claim 13, it would have been obvious to a person having ordinary skill in the art to include actuators in Smoot's spherical device that enable the device to "execute communicative or emotionally evocative movements" such as a "a head nod, a shake, a tremble, or a spin" as taught by Wilson. *See*, ¶¶ 102-103.

g. *Claim 15: "a processor to control at least one or more illumination sources to illuminate at least a portion of the spherical housing"*

106. Wilson's self-propelled spherical device includes a display device such as an array of LEDs, which are controlled by a processor 114 to illuminate the spherical housing:

> Display 118 presents information to outside devices or persons. Display 118 can present information in a variety of forms. In various embodiments, display 118 can produce light in colors and patterns, sound, vibration, music, or combinations of sensory stimuli.

Ex. 1010, *Wilson* at [0047].

> In one embodiment, display 118 is an emitter of light, either in the visible or invisible range. Invisible light in the infrared or ultraviolet range is useful, for example to send information invisible to human senses but available to specialized detectors. In one embodiment, display 118 includes an array of Light Emitting Diodes (LEDs) emitting various light frequencies, arranged such that their relative intensity is variable and the light emitted is blended to form color mixtures.
>
> In one embodiment, display 118 includes an LED array comprising several LEDs, each emitting a human-visible primary color. Processor 114 varies the relative intensity of each of the LEDs to produce a wide range of colors. Primary colors of

> light are those wherein a few colors can be blended in different amounts to produce a wide gamut of apparent colors. Many sets of primary colors of light are known, including for example red/green/blue, red/green/blue/white, and red/green/blue/amber. For example, red, green and blue LEDs together comprise a usable set of three available primary-color devices comprising a display 118 in one embodiment. In other embodiments, other sets of primary colors and white LEDs are used.

Id. at [0048]-[0049].

107. Wilson further suggests using the LEDs to communicate information such as the device state to the user:

> In variations, the sensor/input control logic 721, 723 is used to control other aspects of the self-propelled device 710. In embodiments, the sensor/input control logic 721, 723 may execute runtime program 716A instructions to generate a state output 727 that controls a state of the device in response to some condition, such as user input our device operation condition (e.g., the device comes to stop). For example, an illumination output (e.g., LED display out), audio output, or device operational status (e.g., mode of operation, power state) may be affected by the state output 727.

Id. at [0127].

108. In my opinion, it would have been obvious to a person of ordinary skill in the art to similarly include LEDs on the spherical housing of Smoot's self-propelled device. As suggested by Wilson, it would be advantageous to enable Smoot's processor to control the LEDs in order to communicate information, such as device state, to the operator. Given the high degree of similarity between Smoot's

spherical device and Wilson's spherical device, it would have been obvious to improve similar self-propelled spherical devices in the same way.

109. As I discussed in the Background of the Technology section, using lights on a self-propelled, spherical robot to communicate information such as emotion to a human user was also known for over a decade prior to the '920 Patent. *See*, ¶ 48. Wilson similarly teaches using lights in combination with actuators "to execute communicative or emotionally evocative movements:"

> However, it should be appreciated that actuators 126, in various embodiments, produce a variety of movements in addition to merely rotating and translating device 100. In one embodiment, actuators 126 cause device 100 to execute communicative or emotionally evocative movements, including emulation of human gestures, for example, head nodding, shaking, trembling, spinning or flipping. In some embodiments, processor coordinates actuators 126 with display 118. For example, in one embodiment, processor 114 provides signals to actuators 126 and display 118 to cause device 100 to spin or tremble and simultaneously emit patterns of colored light. In one embodiment, device 100 emits light or sound patterns synchronized with movements.

Id. at [0056].

110. As such, a person of ordinary skill would have understood that enabling Smoot's processor to control LEDs on the device's spherical housing would have predictably improved the device's ability to also communicate "emotionally evocative" information to the operator as taught by Wilson.

h. *<u>Claim 16: "wherein the processor illuminates each of the one or more illumination sources as a feedback response to a user interaction</u>"*

111. I have been informed by counsel that the broadest reasonable interpretation of this claim limitation must at least include a user interaction with a controller resulting in the self-propelled device's processor altering the illumination output. Wilson describes an embodiment where a user interaction with the remote controller device causes the self-propelled device's processor to alter illumination output:

> In some embodiments or implementations, the input generated on the computing device 750 is interpreted as a command and then signaled to the self-propelled device 710. In other embodiments or implementations, the input entered on the computing device 750 is interpreted as a command by programmatic resources on the self-propelled device 710. By interpreting user input in the form of commands, embodiments provide for the self-propelled device 710 to respond to user input in a manner that is intelligent and configurable. For example, the self-propelled device 710 may interpret user input that is otherwise directional in nature in a manner that is not directional. For example, a user may enter gesture input corresponding to a direction, in order to have the self-propelled device 710 move in a manner that is different than the inherent direction in the user input. For example, a user may enter a leftward gesture, which the device may interpret (based on the runtime program 716A) as a command to stop, spin, return home or alter illumination output, etc.

Ex. 1010, *Wilson* at [0123].

112. It would have been obvious to a person having ordinary skill in the art to similarly enable Smoot's processor to alter the LED illumination output based on

a user's interaction with a controller device as taught by Wilson. A skilled artisan would have understood that user inputs need not be limited to commands relating to control of the IDU. Rather, it would have been obvious to enable the processor to interpret user inputs as commands to control other components of the spherical device, such as the LEDs as well. Allowing a finer degree of control over Smoot's spherical device by allowing the user to control illumination output of the LEDs would have predictably allowed the user to customize operation of the device to his or her liking. Therefore, it would have been obvious to improve similar spherical robotic devices in the same way.

i. *Claim 17: "wherein the spherical housing includes two hemispherical shells which are structured to open and allow access to internal electrical components of the self-propelled device"*

113. Smoot's self-propelled spherical device includes a spherical body and internal electrical components, such as the IDU and its associated processor, held within the spherical body. Ex. 1009, *Smoot* at Fig. 10. Smoot does not describe how one would access these internal electronic components. Nonetheless, a person having ordinary skill in the art would expect Smoot's spherical body to include some mechanism for allowing access to the internal electronics.

114. The housing of Wilson's self-propelled spherical device includes two hemispherical shells with an associated attachment mechanism that is structured to open and allow access to the device's internal electronic components:

> In one embodiment, the envelope comprises two hemispherical shells with an associated attachment mechanism, such that the envelope can be opened to allow access to the internal electronic and mechanical components.

Ex. 1010, *Wilson* at [0092].

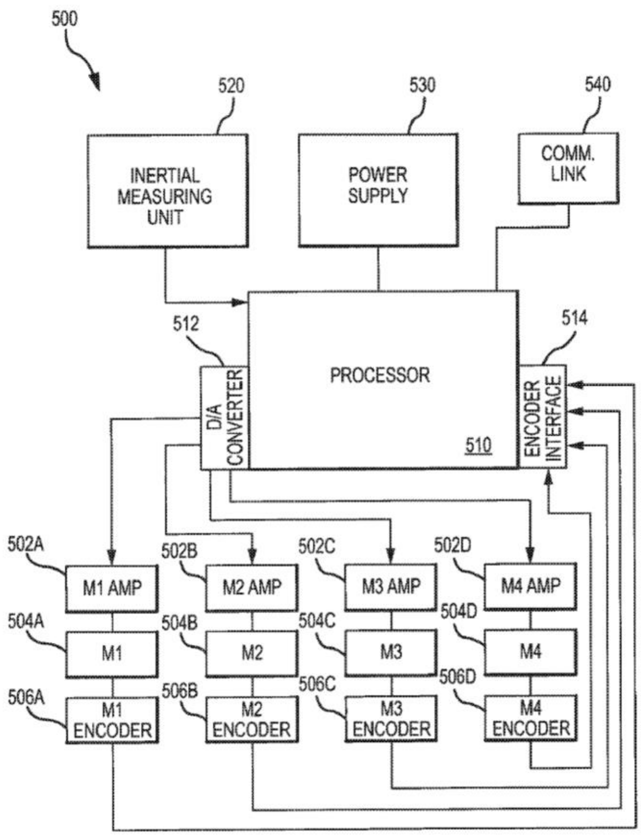
> As shown, robotic ball 300 includes an outer spherical shell (or housing) 302 that makes contact with an external surface as the device rolls. In addition, robotic ball 300 includes an inner surface 304 of the outer shell 302. Additionally robotic ball 300 includes several mechanical and electronic components enclosed by outer shell 302 and inner surface 304 (collectively known as the envelope).

Id. at [0090].

115. It would have been obvious to a person having ordinary skill in the art to construct Smoot's spherical body out of two hemispherical shells structured to open via an associated attachment mechanism as taught by Wilson. A skilled artisan would have expected some mechanism allowing the user to access Smoot's internal electronic components for purposes of repair, for example. Constructing Smoot's spherical body as suggested by Wilson would have the predictable result of enabling access to the device's internal electrical components. As such, it would have been obvious to improve similar spherical robotic devices in the same way by providing the spherical device as two hemispherical shells structured to open to allow access to the internal components.

j. *<u>Claim 18: "wherein the internal electrical components of the self-propelled device include an energy storage</u>"*

116. The internal electrical components of Smoot's self-propelled device are powered by a power supply 530. Ex. 1009, *Smoot* at 12:58-61 ("The controller 510 further may include a power supply 530 that is capable of supplying power to the various components of the controller 510 (e.g., motors 504A-D, amplifiers 502A-D, etc.).").



Id. at Fig. 5.

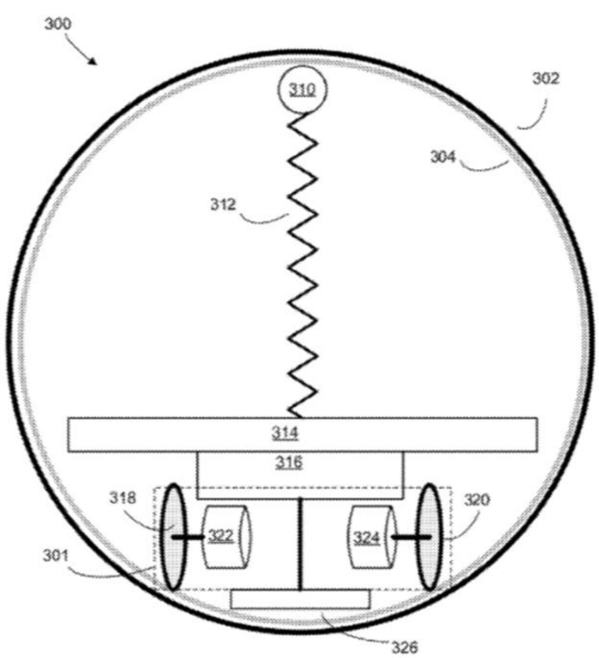
117. A person having ordinary skill in the art would understand that power supply 530 would necessarily be an energy storage device such as a battery. A skilled artisan would appreciate the only alternative to having internal energy storage

would be an external energy source, which would require a power cord or tether. However, a power cord or a tether would be impractical and completely negate the mobility offered by the spherical design of the device.

118. Alternatively, the internal electrical components of Wilson's self-propelled spherical device include an energy storage such as a rechargeable battery:

> Carrier 314 is in mechanical and electrical contact with energy storage 316. Energy storage 316 provides a reservoir of energy to power the device and electronics and is replenished through inductive charge port 326. Energy storage 316, in one embodiment, is a rechargeable battery. In one embodiment, the battery is composed of ithium-polymer cells. In other embodiments, other rechargeable battery chemistries are used.

Ex. 1010, *Wilson* at [0094].



Id. at Fig. 3.

119. It would have been obvious to a person having ordinary skill in the art to utilize an energy source, such as a rechargeable battery, as the power supply within Smoot's self-propelled spherical device. Rechargeable batteries are well known power supplies and are commonly used to power electrical components within self-propelled devices. *See, e.g.*, Ex. 1017, *Martin* at Fig. 4 (ref. no. 64), 3:11-14. As such, the simple substitution of a Smoot's power supply with an energy source such as a battery as taught by Wilson would have yielded the predictable result of powering the internal electrical components of Smoot's spherical device.

F. <u>Obvious to Combine Smoot, Wilson, and Van Kommer</u>

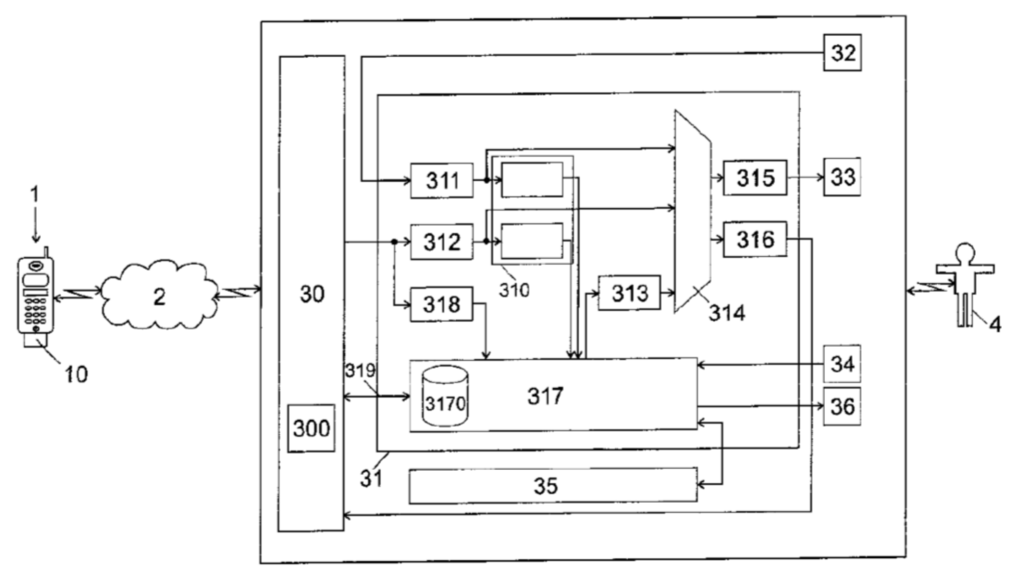
120. I have also been asked to evaluate whether or not it would have been obvious to a person having ordinary skill in the art at the time of the '920 Patent to combine Smoot, Wilson, and Van Kommer to meet certain limitations of the Challenged Claims.

121. U.S. Patent No. 6,584,376 to Van Kommer describes voice-control system for an autonomous mobile robot. Ex. 1011, *Van Kommer* at Abstract. Van Kommer's mobile robot includes a displacement module 35 (IDU), which may be an electric motor driving wheels, for example. *Id.* at 2:55-57 ("The robot illustrated in FIG. 1 comprises a displacement module 35, for example an electric motor, driving the wheels (not represented) and controlled by the processing unit 31."). The IDU is controlled by a processing unit 31, which is a micro-processor or similar

"able to execute a program to control the robot's functions, notably its displacements, according to signals sent by one or several sensors on the robot and/or to high-level commands sent to the robot by an operator." *Id.* at 2:44-52.

a. *Claim 9: "wherein the hardware component receives the user input directly from the user, and wherein the user input causes the drive system to maneuver the spherical housing in a particular manner that is determined from the user input by the hardware component"*

122. I understand that Claim 10, which depends from Claim 9, allows for "the user input directly from the user" to include "a voice command." Ex. 1001 at Claim 10. Van Kommer describes an autonomous mobile robot controllable via voice commands received from a user either over a mobile telephone or "within earshot of the mobile robot to control displacements of the mobile robot." Ex. 1011, *Van Kommer* at Abstract. Van Kommer's mobile robot includes, among other things, an IDU 35, a processing unit 31, and a microphone 32:



Id. at Fig. 1.

> "Mobile robot" in the context of the following description and claims should be understood as a robot provided with autonomous displacement means 35, for example wheels, and with a processing unit 31, for example a micro-processor, micro-controller or computer able to execute a program to control the robot's functions, notably its displacements, according to signals sent by one or several sensors on the robot and/or to high-level commands sent to the robot by an operator.

Id. at 2:44-52.

> The robot illustrated in FIG. 1 comprises a displacement module 35, for example an electric motor, driving the wheels (not represented) and controlled by the processing unit 31.

Id. at 2:55-57.

> The robot 3 includes furthermore a microphone 32 and other sensors 34, for example a camera, a touch sensor, an accelerometer, a radar, biometrics sensors etc., which allow it to perceive its environment.

Id. at 3:1-4.

123. The microphone receives voice inputs from the user 4, which are shaped by a module 311 and input to a multiplexer 314 of a voice analysis module 310:

> The processing unit 31 comprises a module 311 for shaping the signal of the microphone 32; the module 311 can for example comprise an amplifier, a filter and an analog-numeric converter at 8 KHz for example.

Id. at 3:33-36.

> The shaped signals of the microphone 32 and of the mobile phone 30 are supplied at the input of a multiplexer 314 and of a voice analysis module 310.

Id. at 3:45-47.

> In the case of a robot controlled by a single operator 1 or 4, the voice analysis module can then be trained to analyze that operator's voice, for example during a training stage ("speaker-dependant [sic] recognition").

Id. at 3:56-59; *see also, id.* at Fig. 1.

124. The voice analysis module "recognize[s] voice commands intended for the robot in the voice flux coming from the microphone 32." *Id.* at 3:47-52. The decoded commands are input to sequential machine 317, which is a computer program executed by the processor that generates control signals for the IDU based on the decoded voice commands and other sensor input (e.g., accelerometer, camera, etc.):

> The voice analysis module 310 can for example use a neural network, hidden Markov networks or a hybrid system, and is trained to recognize voice commands intended for the robot in the voice flux coming from the microphone 32 and the mobile phone 30.

Id. at 3:47-52.

> The commands decoded by the voice analysis module 310 are supplied at the input of a sequential machine 317, comprising preferably a computer program stored in a memory zone and a processor able to execute this computer program.

Id. at 3:60-64.

> The state of the sequential machine 317 can furthermore depend on signals supplied by the other sensors 34 and by the displacement module 35.

> The state of the sequential machine 317 determines the value of the control signals supplied by this machine, notably a control signal of the multiplexer 314, control signals of the displacement module 35, control signals of the telephone interface 30, control signals of a voice synthesizer 313 and control signals of the reproduction organs 35, for example a display 36.

Id. at 4:3-12.

125. Exemplary predefined voice commands that control displacement of the mobile robot include "high-level commands such as 'forward', 'left', 'stop', 'return to station', 'seize object' etc." *Id.* at 6:18-22.

126. In my opinion, It would have been obvious to a person having ordinary skill in the art to enable Smoot's spherical device to receive and obey voice commands from the operator as taught by Van Kommer. Specifically, it would have been obvious to incorporate a microphone, a voice signal-shaping module, a voice analysis module, and a sequential machine into Smoot's internal controller. As described in Van Kommer, the voice input could be received by the microphone, shaped by the shaping module, decoded by the voice analysis module, and input to a program stored on the memory of the processor that generates control signals for the IDU based on the received voice command. Incorporating Van Kommer's voice control circuitry into Smoot's spherical device would have yielded the predictable result of enabling an operator to control Smoot's spherical device via voice commands.

127. As I discussed in the Background of the Technology section, voice control features have been implemented in mobile robots well prior to the '920 Patent in order to make them more easily operated by laypersons. *See*, ¶ 47. Van Kommer, which issued in 2003, further acknowledges that voice commands were well known in robotics for many years prior to the '920 Patent and that enabling a robot to be controlled via voice commands "offer[s] more flexibility for controlling the mobile robot." Ex. 1011, *Van Kommer* at 1:46-50; *see also*, *id.* at 1:36-40 ("Mobile robots controlled by voice commands are also known and are used for example, although not exclusively, in the entertainment and toy industry. These robots are able to analyze vocal commands of a nearby operator and to obey these commands."). Given these known benefits, a person of ordinary skill would have been motivated to utilize well-known voice control technology to improve the operator's ability to control Smoot's spherical device. Additionally, it would have been obvious to use known voice control technology to improve similar mobile robotic devices in the same way.

128. A skilled artisan would further understand that any modifications to Smoot's internal controller would not impact any mechanical characteristics of the spherical device such as, for example, its ability to maneuver on a surface. Therefore, incorporation of Van Kommer's voice controls would not change the principle of operation of Smoot's spherical device nor render it inoperable for its

intended purpose. A skilled artisan would also understand that Van Kommer's voice controls could be used to control Smoot's spherical device in addition to Wilson's remote controller device.

b. *Claim 10: "wherein the user input corresponds to a voice command, and wherein the hardware component comprises a processor to interpret the voice command as a directional command to cause the drive system to maneuver the spherical housing in a particular direction"*

129. As I discussed above with regard to Claim 9, Van Kommer teaches that voice commands may be directional commands, such as "forward" or "left," that cause the IDU to maneuver the mobile robot in a particular direction. Ex. 1011, *Van Kommer* at 6:18-22. For same reasons given above with regard to Claim 9, it would have been obvious to a person having ordinary skill in the art to modify Smoot's internal controller to include Van Kommer's voice control circuitry to enable the internal controller's processor to interpret voice commands, including directional commands, and cause the IDU to maneuver the spherical housing in a particular direction. *See*, ¶¶ 126-128

IV. CONCLUSION

130. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the

like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: 20 April 2017

By: ____________________________________
Jason Janét